The
ENGINEERS' DIGEST
REVIEW OF WORLD ENGINEERING PROGRESS
VOL. XIV No. 7. JULY, 1953

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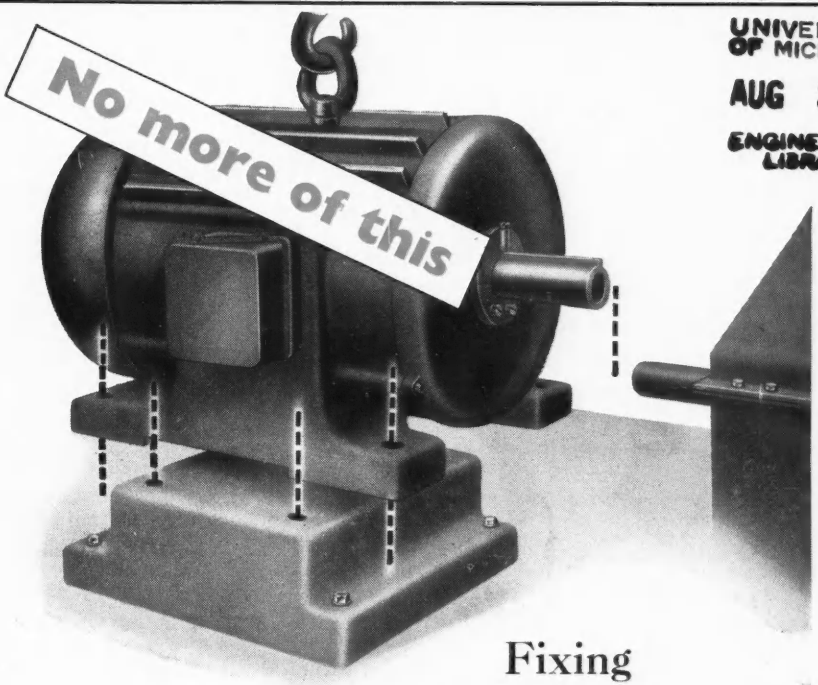

Fixing dimensions standardized

Leading motor manufacturers in this country have collaborated in the design of a range of totally-enclosed fan-cooled, foot mounting, squirrel cage motors having outputs from ¾ h.p. up to 25 h.p. These machines, rating for rating, will all be built to the same leading dimensions which will be laid down in a British Standards specification.

This move to standardize motor fixing dimensions meets a widespread demand and will ensure that when motor replacement is necessary, lost production time is reduced to a minimum.

METROVICK are manufacturing a new range of machines which comply fully with British Standard Draft Specification CN (ELE) 6814. The M.V. range is known as:

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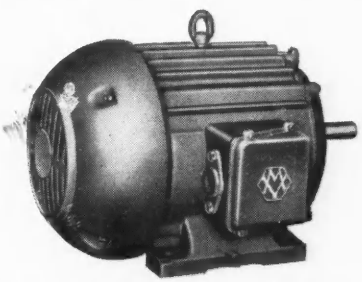

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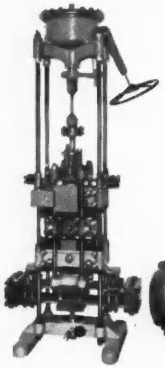
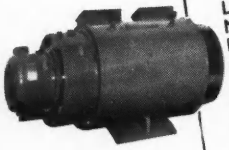
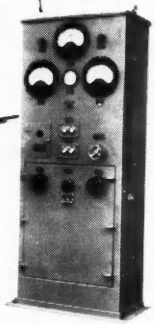




Here is an example of a Special Equipment

The illustration shows a 6-ton Alternating Stress Testing Machine by Messrs. Bruntons (Musselburgh) Ltd., together with a variable voltage Combined Motor Alternator with overhung exciter including Panel comprising Push Button operated starter for motor, Automatic Voltage Regulator for exciter, with coarse, fine and vernier voltage control, specially designed for and supplied to Messrs. Bruntons (Musselburgh) Ltd., the manufacturers of the Haigh Alternating Stress Testing Machine.



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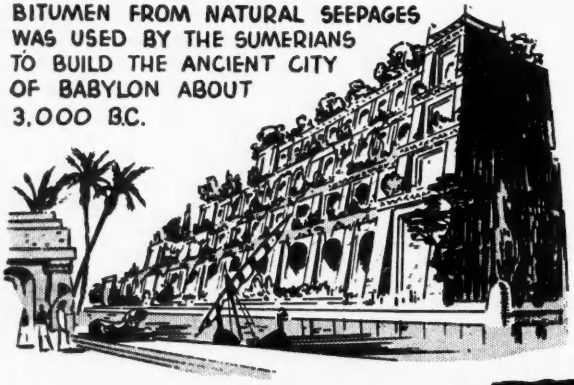

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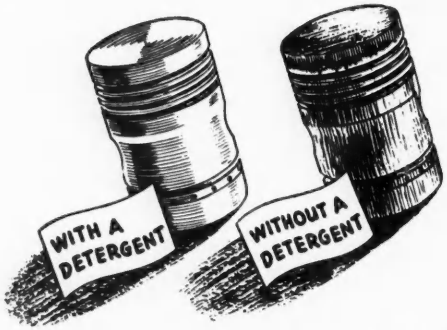

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THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● *PRESSURE WELDING*

Pressure welding, or solid-phase welding as it is also termed, has attracted considerable attention in recent years. It is true that in the early stages of development considerable trouble was experienced in obtaining consistent results, but the fact that the process is now in full commercial use, although still on a limited scale, bears witness to the utility of the process as such. It is not always realized that this process is basically different from ordinary welding methods. Infusion-welding metallic contact is achieved by the use of molten metal, with or without a flux. Once intimate contact has been produced by the merging of molten metal or by the wetting of solid metal by molten metal, solidification produces a continuous crystalline structure between the faying surfaces and a sound weld is obtained. The molten metal serves two vital functions: (1) it eliminates the need for smooth faying surfaces to secure intimate metallic contact, because molten metal accommodates itself to the contour of the metal being joined; and (2) the molten metal, with the help of fluxes or parent metal melting, removes non-metallic flames from the surfaces being welded, thus assuring intimate metallic contact. In pressure welding, no molten metal is present to perform these two essential functions; some other mechanism must function to accomplish this vital need. Careful study and analysis have shown that this mechanism is recrystallisation and that the so-called pressure-welding process should be more correctly known as recrystallisation welding. The fundamental mechanism causing recrystallisation is not as yet established, although there are several postulates concerning it. No explicit relationship relating quantitatively the dependence of recrystallisation temperature to the deformation has yet been found. Metallurgists have been content to observe that the greater the degree of deformation, the lower will be the recrystallisation temperature, and have contended that the many variables involved defy statistical analysis of the limited data available.

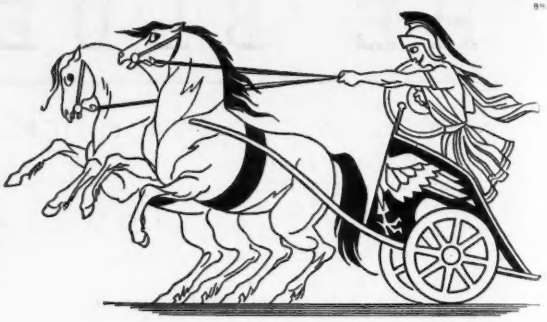
● *HIGH-SPEED AIR SPINNER FOR CENTRIFUGAL TESTING*

A simple high-speed air spinner has been developed for the centrifugal testing of small mechanical and electro-mechanical devices while spinning at speeds up to 60,000 rpm. The spinner represents a variation of the air spinning-top originated by French scientists. It consists of a rotor supported and driven by air and is capable of high angular velocities with relatively insensitivity to static unbalance; bearing problems are completely eliminated. When constructed properly, a spinning-top rotor is extremely stable. While the rotor is spinning, sizable weights can be suddenly shifted internally without visible effect on rotor stability. However, extreme static unbalance causes the rotor to chatter against the sides of the stator. Such a rotor can also be spun in an inverted position, being held in the stator by the Bernoulli forces.

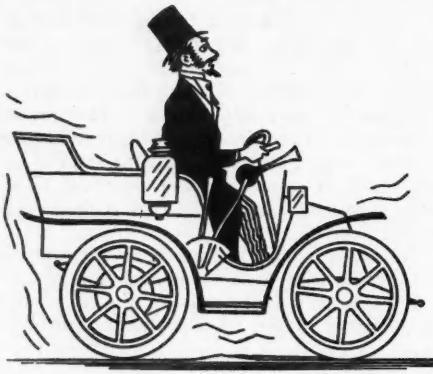
While large static unbalance is permissible, dynamic balance has to be maintained more closely. For this reason, it is difficult to spin tall small-diameter rotors. Good rotor design requires that the moment of inertia in the plane of rotation be large. If this is done, precise balancing is not necessary. Properly designed rotors are extremely stable at high spinning speeds, and the driving air pressure can be changed suddenly without upsetting rotor stability. Variations of this spinner can be put to many uses. These include the timing of clock mechanisms, stroboscopic inspection, and study of detent and rotor actions. Another application is in high-speed photographic studies of clock escapement action under spin conditions, and in off-centre spinning of various mechanisms. With a spinner of $1\frac{1}{4}$ in. diameter, speeds as high as 120,000 rpm can be obtained where required.

● *ELECTROPHORETICALLY PRODUCED REFRACTORY COATINGS*

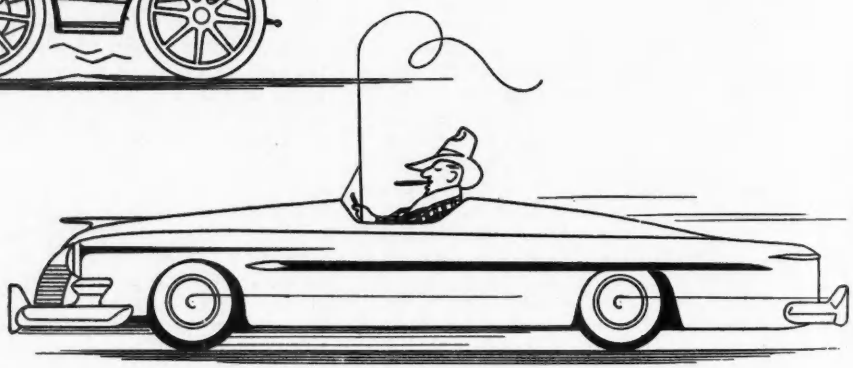
A recent patent gives interesting details of a novel electrophoretical process of covering gas turbine blades with refractory coatings in order to make them more resistant to high temperature. In a specific case, the blades are made of nickel-chrome alloy and are first thoroughly cleaned to prepare the surface for coating. The slurry from which the coating is deposited consists of silica sol mixed with one or more finely ground refractory filler materials such as silica, alumina, the aluminium silicates, talc, and certain other substances. In order to ensure complete consistency of the process, the cathode and the turbine blade are preferably assembled in a jig for immersion in the slurry mixture. To produce a coating of even thickness, the jig should be such that the anode to cathode distances are equivalent at all parts, i.e., the distances are such that they produce the same



FASHIONS CHANGE



WITH AGE AND RACE–



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rate of deposition on all parts, so that the surface is built up evenly and of uniform thickness. For a blade of approximately 6 sq. in. surface area, in a silica slurry, the applied potential is from 3·5 to 6 volts d.c., the intensity of the current being from 40 to 150 milliamperes, and the time taken to make a deposit of 0·005 to 0·030 in. thickness is from 2 to 10 minutes. After deposition has continued for the required time, the blade is removed from the slurry and washed in water to remove excess slurry. The washed blade and coating is then dipped in methylated spirit, acetone, or other water-miscible volatile organic liquids, to assist in the removal of surplus water. The final step of the process consists in firing the coated turbine blade in an oven at from 600° C to 750° C for a period of not less than one hour. The final firing temperature is determined by the melting point of the metal upon which the deposit has been made and by the material which has been deposited. Articles made of stainless steel require special treatment because of the passive film present on the surface.

● *PRODUCING LARGE ALUMINIUM ALLOY INGOTS*

To be metallurgically sound for forging and extruding, aluminium alloy ingots must be as uniform as possible in chemical composition, fine in grain structure, and free from cracks and porosities and non-metallic inclusions. However, the larger the ingot, the more difficult becomes this task. The direct-chill method for casting large ingots would appear to hold promise of ultimate success, provided it can be improved beyond its present stage of development. In this method, molten metal is poured into a short, circular water-cooled mould which is temporarily closed at the bottom. After solidification of the aluminium alloy first poured into the mould, the partially solidified ingot is lowered at a controlled rate through direct water sprays. The fast-chilling that results generally gives fine grain structure and less variation in chemical composition than can be obtained with any other method of casting. However, ingots of strong aluminium alloy have a marked tendency to crack when cast by the direct-chill method. This susceptibility to cracking rises both with increase in cross-sectional area of the ingot and with the cooling rate. Unduly rapid cooling will cause the development of stresses owing to temperature differentials prevailing throughout the mass of the metal. On the other hand, an excessively slow cooling rate may also cause trouble. If the heat extraction rate is such that a wide solidification zone results, the gases liberated as the liquid freezes become unable to escape. Moreover, there may not be sufficient liquid available in the " mushy " metal to fill all the interdendritic spaces. It has been found that harmful porosity can be prevented by using " whippers " to remove water from the surface of the ingot a short distance below the mould. This serves to narrow the solidification zone and, by permitting heat to be retained in the bottom portion of the ingot, helps to equalise metal temperatures.

● *GRAPHITE IMPREGNATED SURFACES*

Graphite has been known for many years as one of the most successful dry lubricants ever discovered and has been used by itself for this purpose and also as an ingredient of lubricating compositions. However, dry graphite as ordinarily used, adheres to a friction surface for only a limited time and frequently requires replacement. As the result of a recent invention, graphite may be practically permanently bonded or fused into or onto the surface of articles. In general, the application of graphite as a lubricant involves the steps of preparing the surface for coating, applying finally divided graphite and one or more bonding agents, and completing the process by firing the material in place by means of a heating or baking treatment. The exact procedure to be followed will vary considerably, depending upon the types of surfaces to be treated and the usage to which the coated surface is to be subjected. Iron and steel surfaces may be prepared by either sand-blasting or by a phosphatising treatment, such as bonderising or parkerising. In the case of non-ferrous metals, or austenitic steels, the surface may be prepared by first applying a thin coating of a low melting point alloy such as indium or gallium. Graphite, suspended in a suitable organic vehicle, is then applied, and the graphite coated article heated to a temperature above the melting point of the coating metal, so that the graphite becomes firmly embedded in the coating metal. A preferable procedure is to prepare a mixture of the graphite and the low melting-point coating, each in powder form and suspended in an organic carrier. As a vehicle, copolymers of vinyl chloride and vinyl acetate, mixed with a thermosetting resinous material, may be used.

● *PLATING WITHOUT ELECTRIC CURRENT*

A new chemical coating process has been developed which causes the deposition of a hard nickel plating on either metallic or non-metallic surfaces. It is reported that this process shows considerable promise of superseding conventional electroplating technique in the case of such industrial components as valve bodies, camshafts and crankshafts, tank linings, piping, cams, bearings, pinions, and other machine elements. The main advantages of the process are said to be a low-cost uniform coating, regardless of shape or size of the part, good adhesion irrespective of surface roughness, and little or no porosity. The process in question consists simply in immersing the part to be coated in an agitated solution of nickel chloride and sodium hypophosphite, held

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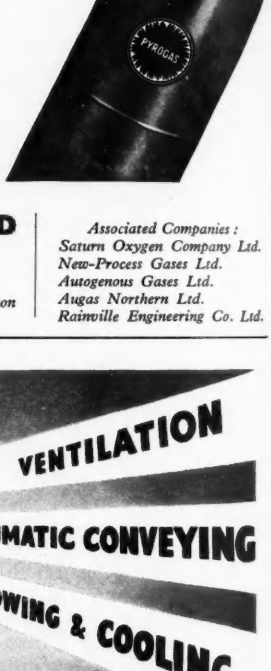

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at a temperature of 100° C. Nickel will then deposit at the rate of 1-2 thousandths of an inch per hour depending on bath concentration, to form a plating or coating with a hardness of 550 to 650 Vickers units. By special means, including variations in the plating technique and/or heat treatment, hardness as low as 400 Vickers or as high as 900 Vickers can be obtained. The solution is relatively inexpensive and can be prepared from readily available chemicals. It is harmless and not appreciably corrosive. Although the process might be extended to include deposition of additional metals, it has certain limitations. Thus, for instance, it is doubtful if it would ever be possible to apply it to an active material such as chromium. To permit deposition by controlled hypophosphite reduction, a metal must be capable of catalysing the decomposition of the phosphate salt. Only metals of this type are capable of receiving a nickel deposit by this method. Since neither design nor size presents an obstacle, large vessels, tanks, chemical process equipment, and bulky objects in general can be given a continuous coating of nickel of any desired thickness.

● *VACUUM FORMED THERMOPLASTICS*

Vacuum moulding, a technique for forming thermoplastic parts of large area and thin sections, is now receiving considerable attention. This method makes use of heated sheet stock which is shaped by exhausting the air from under the sealed sheet and letting atmospheric pressure press a plastic sheet into the mould. Some of the outstanding features of vacuum moulding technique are: It makes possible the forming of large thin pieces which cannot be moulded in a closed mould; mould costs are greatly reduced; and the equipment needed is simple and requires no large capital investment. A drawback is that surface finish at the present stage of development is not as lustrous as with other moulded pieces. Materials which can be formed by the vacuum method include the cellulosics, polystyrene and some other vinyls. Polystyrene because of its combination of good properties with low cost is in especial favour with manufacturers. Low-cost moulds work very well with vacuum forming and the possibility of achieving important savings in tool cost represents one of the most significant advantages of the process. As the mould itself is under no stress greater than atmospheric pressure, forms can be made of wood, plaster, soft metal, etc., and can thus be easily worked at minimum cost. The machine employed to carry out the process is simple in design, has no highly stressed parts, and does not call for high precision in manufacture or for the use of unduly expensive materials. The process is started by placing the mould in the vacuum box and laying a sheet of a plastic material over the top of the box. A heating device is then moved over the sheet and a temperature of some 600-700° F is then applied. The air inside the box is then exhausted, so that atmospheric pressure will force the heated sheet down over the mould, thus making the sheet follow closely the contours of the latter.

● *RADIANT GLASS HEATING PANELS*

In recent years the employment of glass heating panels as a means of heating private dwellings has come into increasing use in America. Recent scientific tests indicate that electrically heated radiant glass panels constitute a satisfactory method of space heating. There is no doubt, however, that this type of electric heating will be considerably more expensive than heating by either coal, oil or gas, and it can safely be predicted that in Great Britain a heating system of this type will not find very widespread application except, perhaps, in cases where the use of other types of electric space heating is not considered desirable owing to the localised high temperatures produced, as, for instance, possibly in hospitals, nurseries, etc. The typical radiant glass panel is mounted on a metal frame and backed by a reflecting shield from which it is separated by a small air space. A metallic coating on the rear surface of the glass serves as the electric conductor and heating element. A typical panel has an output of 1,000 watts but other sizes can, of course, be made as required. Heat is transmitted from these panels primarily by radiation and convection. When the panel is heated above the room air temperature, heated air passes upward over the face of the panel through the space between the glass and the reflecting shield, and between the shield and the frame of the panel assembly. At the same time, radiant heat is emitted outward from the face of the panel. The passage of air through the spaces back of the glass keeps the temperature of the rear of the assembly cool enough to allow it to be in contact with combustible materials. One type of glass panel was subjected to thermal shock tests in order to ascertain whether cracking of the glass might result from sudden exposure to water spray. These tests showed that the panel was relatively insensitive to such treatment. However, mechanical tests show that the panel has a certain weakness in resistance to mechanical shock around the edges.

● *RESIDUAL STRESSES IN METALS INTRODUCED BY FABRICATION*

A recent paper outlines the advantages and disadvantages of residual stresses in metals and gives examples of investigations into such stresses and methods of measurement. The effects of fabricating practices are also considered and relief by thermal treatments, mechanical treatments, and a combination of the two, is discussed. Investigations have shown that the residual stress in aluminium alloy square tubes used in the main spar trusses of four-engined aircraft and produced by

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Armour of Robert Dudley Earl of Leicester (1531-88)

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cold sinking after solution heat treatment, was very high, in some cases, 65,000 psi tension, the yield strength of the alloy. By heat treating the tube after being drawn square, instead of before, there was some reduction in mechanical properties but no further cracks were encountered in service. Residual stresses are generally measured by mechanical or by X-ray methods, but the former are destructive and the latter give surface stresses only. The paper includes the results of a study of the effects of fabricating practices upon cast and wrought aluminium alloys. Quenching temperature, quenching rate, section size composition, and tensile properties are the variables considered. In addition, the effects of re-heating time and temperature on the magnitude and distribution of retain stresses are discussed. When the balance between relatively high residual stresses in metal products, especially those having heavy or thin sections, is disturbed by machining, undesirable distortional or dimensional changes may result. Relief by mechanical treatments includes stretching, repeated bending, and coining. Aeroplane spar chord sections with a cross-section of 60 sq. in. can be successfully stretched. An example of relief by a combination of thermal and mechanical treatments is a relatively new method for simultaneously forming, quenching, and stretching high-strength aluminium alloy parts by a die-quenching process.

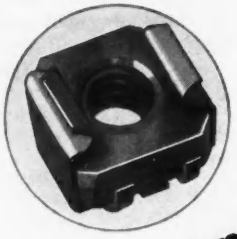
● *MAGNETIC TAPE RECORDING FOR PRECISION DATA*

Many new forms of recording have been used in recent years. One of the latest and most versatile forms is magnetic tape recording. While its usefulness in high fidelity audio-recording is unquestioned, its applications in the fields of instrumentation and telemetering are not so well known. A recent paper discusses a special carrier system, wherein signals from zero to 10,000 cps may be recorded. A typical model operates at 30 in. per second, allows 60 minutes of recording and records from zero to 5,000 cps. In order to achieve a response of up to 10,000 cps, the recording time is simply cut in half. Special machines have also been built to operate at 0·3 in. per second to give a recording time of 27 hours, with a frequency range from zero to 20 cps, a 135 cycle carrier being used. Such machines can record at fast speeds and play back at slow speeds or *vice versa*. In general, magnetic tape recording offers many advantages. The carrier system is proving very useful for the recording of low frequency disturbances, power line transients, seismic exploration signals, strains in structures, and for many other varied purposes. It can be used to record signals which are too high in speed for a pen recorder ; it can be played back at a slow rate to drive a pen recorder, thus giving an easy and convenient visual picture of a permanent nature. Alternatively, if only a certain portion of the recording is of interest, the tape containing it can be made into a loop and can be played repeatedly, if required. A visual indication can be given on an oscilloscope. A standard drive mechanism is used for the device, and the electronic system is claimed to be comparatively simple. No doubt, there exist many cases either in the laboratory or in industrial plants where the use of instruments of this type will prove of great value and where the comparative simplicity of their application will prove particularly attractive.

● *RADAR PREVENTION OF AIR COLLISIONS*

The acceptance by the public of air travel as a safe and economical means of transportation has resulted in a meteoric growth of commercial air lines. Unfortunately, air navigation and control facilities have not kept pace with the increasing density of air travel, and traffic control facilities still fall short of the actual need. The combination of these factors has resulted in a severe air-to-air collision problem. Pulse radar is inadequate for air-to-air collision warning for the following reasons : Firstly, aircraft echoes are not usually strong enough to be arresting when presented on the screen of a cathode-ray tube, and at low altitudes especially, where ground echoes are strong, aircraft echoes are masked by ground clutter. Secondly, the use of the cathode ray tube for visual indication necessitates continuous surveillance of the screen by the pilot ; this imposes an additional strain upon his attention and is neither desirable nor practical. Finally, even if a target were noticed on the radar screen, only its present position would be shown. The radar screen would tell the pilot where the aircraft is at a given moment but not where it is going. Fortunately, continuous wave radar, while not as familiar as pulse radar, has characteristics which make it attractive for the task of collision warning. As its name implies, continuous wave radar transmits energy continuously, while pulse systems emit energy in bursts. The required characteristics of a continuous wave radar for the purpose of collision warning are achieved by employing a system of frequency modulation. One of the outstanding advantages of a continuous wave radar is that the closure rate of a target can be measured by utilising the Doppler effect. Radar signals reflected from moving targets are subject to an apparent frequency shift, proportional to the closure rate of the target. Measurement of the Doppler shift provides a convenient and accurate means for determining the closure rate.

For further information on developments reviewed in THE BLUE PAGES, readers are invited to write to the Editor.



For Simmonds "Spire" nut Grips

Yet another example of a well-known product incorporating S. B. & N. strip is the "Spire" Nut Grip made by Messrs. Simmonds Aerocessories Limited, Glamorgan, by whose courtesy this illustration is reproduced. The S. B. & N. Cold Rolling Department specialises in the production of high carbon and alloy steel strip within the size range ·004" to ·048" thick, 4" maximum width.

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THE ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

VOL. XIV. No. 7. JULY, 1953

A Cloud on the Horizon

At this time of the year, when we have a reasonably optimistic expectation of at least some sunshine, it is perhaps a little tactless to call the attention of our readers to a cloud on the horizon. This, nevertheless, must be done, for we are speaking of no metaphorical cloud but of a very real and ominous one. That cloud is smoke.

We are all only too familiar with smoke and familiarity, we are told, breeds contempt. That, probably, is why we are so inclined to accept its presence with such good-natured tolerance. We are also told, however, that the surest way to lose a battle is to under-estimate one's enemy, and—let us make it quite clear—Smoke *is* an enemy, a ruthless, insidious, implacable enemy who, with his satellite Fog, accounted for no less than 4000 lives in greater London alone during the first weeks of last December.

War is always a costly affair and estimates show that indirect damage through smoke costs this country about £100 million per year. Thanks, however, to the efforts of the National Smoke Abatement Society and its journal[1], attempts are being made to call attention to this wanton waste of life and property, and there are at last some signs that the public is being made conscious of the issues involved.

It is to be hoped that what should be regarded as a matter of prime national importance will not be treated in Westminster with customary apathy. The Usual Questions have been asked in Parliament and the Government has made the Usual Decision to appoint the Usual Committee under the Usual Chairman to make the Usual Enquiry into the causes of and remedies for air pollution. This seems to imply that air pollution is being treated as if it were some unknown epidemic. However, the problem of smoke is not new. Its causes are only too well-known and remedies have been suggested in scores of scientific papers, among which, to take only two of the more recent ones, we may mention Dr. Meetham's book[2] and the Proceedings of the U.S. Technical Conference on Air Pollution[3].

Official pronouncements seem to indicate that it would be futile to think that the smoke nuisance can be abolished "overnight." As a method of pigeon-holing the problem, this ponderous dictum is no doubt admirable, but that is all one can say for it. No one expects an overnight cure but, whether it takes years or even decades is immaterial, provided the cure is initiated and brought to its conclusion.

Clearly, legal control of the fuel supply is essential as a preliminary step towards clean air. How this was done in St. Louis and Pittsburgh, once two of the smokiest cities in America, is described in the above Proceedings[3]. The campaign for abolition of smoke in these cities was the direct result of civic agitation and a determination to deal positively and effectively with the smoke nuisance. It took seven years to accomplish the task, but today St. Louis and Pittsburg are no longer a menace to their communities.

These Proceedings[3] make interesting and instructive reading and we recommend them to the Government for study and attention. What has been done in America can be done in Great Britain, and if civic conscience is found to be sluggish, then it should be left to National conscience to assume control.

We do not say that civic conscience is entirely dead. Manchester, we know, has a 104-acre smokeless zone in the centre of the city, in which some 2200 open grates no longer burn coal but are fed with low-temperature carbonised fuel. We are aware, too, that, according to a report in the *Manchester Guardian* of June 24, 1953, the Manchester Health Committee has decided to recommend that this zone should be more than doubled—a decision which merits the highest praise.

We are also aware, however, that in the same report it was stated, at a conference organised by the Combustion Engineering Association, that a member of the National Coal Board deprecated the large-scale extension of such smokeless zones on the ground that "the smokeless fuel is not there; it will not and cannot be there in the immediate or . . . foreseeable future." It is gratifying to note that this remarkable invitation to let-well-alone was not allowed to pass unchallenged by several members of the conference.

At this stage, we expect a chorus of rebuke for inconsistency, inasmuch as it is apparent that the smoke nuisance *is* being dealt with. Now, if we have one national failing, it is that of complacency: We invent, we seldom perfect; we initiate, we rarely complete. A start has been made in Manchester, admittedly, but it is not enough. It must be made throughout the whole of Britain and,

above all, it must be made quickly. The open coal fire is inefficient and must go, but this is only a minor detail in the whole pattern of the smoke problem. When the field of operations has been extended to include the main-line railways by the use of diesel or electric traction, and to attend to the belching chimneys of industry, then, and only then, shall we be able, literally, to see our way clear to receiving dividends in health and economy from our investment in clean air.

All great cities and industrial areas throughout the world have or have had to face this problem, and the methods they employ are worth studying. In this connection, we publish below extracts from a book on air pollution by a Soviet author, to show that the Russians appear to be trying to lift one curtain at any rate. The book deals with the theoretical aspects of the problem, and some of the data presented make interesting, at times startling, reading.

As we have already stated, we do not expect the menace of smoke pollution to be removed immediately. We realize it will take time, perhaps a long time. We know that difficult problems are involved, but we know, too, that their solution is not impossible. In short, it is all a question of time (which can and must be spared), of scientific ability (which this country possesses in abundance), and of the will to act immediately (which can be enforced only by the Government).

We earnestly recommend, therefore, that in the purer, and, no doubt hotter, air of Westminster, Parliament refrains for once from exploring avenues already well explored and unturning stones already well turned, and devotes its immediate and practical attention to this problem, even if it incurs the national distaste for profiting by the experience of others.

REFERENCES

(1) *Smokeless Air*, The Smoke Abatement Journal, London. (The spring issue, No. 85, 1953, deals with the London Fog of December 1952).

(2) *Atmospheric Pollution. Its Origins and Prevention.* By DR. A. R. MEETHAM. Pergamon Press, London, 1952.

(3) *Air Pollution.* Proceedings of the United States Technical Conference on Air Pollution. McGraw-Hill Book Company, Inc., New York and London, 1952.

RUSSIA

Some Considerations of Smoke Pollution of Air

By G. W. SHELEICHOVSKI. (From *Die Technik, Germany*, Vol. 8, No. 1, January, 1953, pp. 26-30, 10 illustrations).

The article in Die Technik is condensed from the 226 page Soviet book "Air Pollution of Cities by Smoke." The author, Sheleichovski, spent 13 years investigating air pollution and the theories he developed were apparently confirmed by measurements. The methods of diminution of smoke pollution he proposed have been employed in town-planning, and in the planning of industrial estates in Russia. For the solution of the problem of smoke pollution, Sheleichovski believes that a prime essential is complete co-operation between all authorities concerned, including planning, medical, and local government, but that it is no less important to study and determine by experiment the type and degree of pollution in each particular case.

Some of the theoretical aspects, notably those in connection with the composition and distribution of smoke, and the significance of wind strength and turbulence, are discussed in the following.

IT IS INTERESTING to consider that in many industrial towns air pollution is such that in a period of 24 hours more than 1 gram of ashes, dust and soot fall on one square metre. When these figures are expressed in terms of an area of 1 square mile per annum the results are alarming. The following are approximations for a number of English, American and Soviet cities: London 930 tons; Birmingham 1,230; Baltimore 1,400; Liverpool 2,500; Leningrad 740; Voroshilov 930; Stalino 960; and Charkov 1,170.

The loss of intensity of solar radiation caused by air pollution, as compared with the "clean" air surrounding the city, is about 38 per cent for London and 50 for Leeds. In Leningrad it is about 40 per cent when compared with its suburb Pavlovsk. These figures are understandable when it is realized that a power station discharges into the air about 47 tons of ashes and 95 tons of sulphuric gases per day for each 100,000 kW produced, when burning high-quality fuel. Fuels of inferior quality produce even more fly-ashes (Table 1). These figures are all the more remarkable as, for economic reasons, with present-day power station practice, low-grade fuels are becoming more and more common.

In industrial towns, owing to air pollution by smoke, the onset of dusk is earlier than in rural parts. As a result, excess production of electricity for lighting in Leningrad, for example, is 27 per cent, and is wholly unproductive.

TABLE I. PERCENTAGES OF SULPHUR AND ASH IN SOME FUELS OF THE SOVIET-UNION.

	Sulphur	Ash
Donez anthracite	1·7	9·2
Coal from the Moscow coal basin	2·5	18·2
Kiselov coal	5·8	21·5
Karaganda coal	0·4	36·6
Volga shale	4·1	50·0
Peat	0·2	5·1

Loss of ultra-violet radiation in Leningrad averages 20 per cent, and in its industrial districts up to 40. Incidentally, in London during the winter this figure has reached no less than 97 per cent. Although ultra-violet radiation is only about 1 per cent of the total solar radiation, it is of biological significance in its preventive action against rickets in children.

The effect of air pollution is also felt in the increase of ground fog. For instance, Charkov, before its industrialisation in 1923, had 15 per cent foggy days. From 1927 to 1930, this percentage rose to 30. The islands Sylt and Heligoland average 40 foggy days per year, while Hamburg averages 126 days.

Fly-ashes in polluted air are responsible for a great deal of material damage, often irreplaceable, The retention of the damaging constituents of smoke, before their discharge into the atmosphere, is to-day successful to a remarkable degree. Mechanical filters absorb on an average 65 per cent of fly-ash, cyclones from 40 to 50, multi-cyclones 70 to 90, and wetted electrical precipitators up to 90. However, the efficiency of filters decreases with decreasing load. Much less successful is the solution of the problem of sulphur removal from flue gases.

The Movement of Smoke. The assessment of air pollution becomes possible through a knowledge of smoke distribution. The polluting constituents are solid particles, liquids and gaseous parts, such as ash, soot and sulphuric acid. The smoke stream emitted into the atmosphere behaves as one liquid entering another liquid of a different kind. Mixing takes place in the

same manner as, for instance, that of alcohol and water.

The density of the smoke stream changes continually, whereby the lighter parts rise and the heavier ones fall. The spread and path of a smoke plume are dependent on the wind velocity and the turbulence of the wind. The mean values of atmospheric turbulence at various wind velocities are plotted in Fig. 1, while Fig. 2 gives an

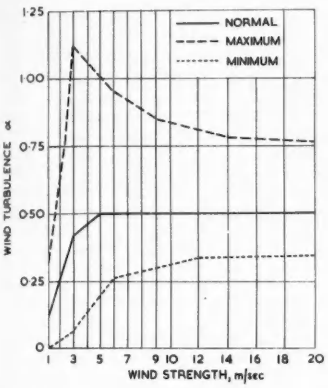

Fig. 1. **Wind Strength $v = v_0 (1 + \alpha)$ against wind turbulence α.**

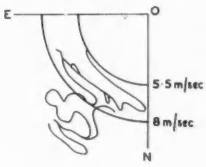

Fig. 2. **Example of variation in change of wind direction in one minute.**

example of the variation in wind direction during one minute. This is generally referred to as wind fluctuation, to be distinguished from wind strength and wind turbulence, which is representative of the micro-structure of the wind and is measured in fractions of a second. The wind fluctuation has a great practical significance with small winds strengths.

The Significance of Wind. As wind is a main factor in air pollution problems, the consideration of the location of industry is based on meteorologically determined wind frequencies and velocities. These data are required at several heights, as modern chimneys can be as high as 100 m or more. It is common knowledge that wind strength and right-deviation of wind increase with increasing height. At a height of 500 m, wind velocity is three times as great, with a right-deviation of 30 per cent.

The various wind velocities and deviations can be conveniently represented by Ekman's wind spiral, Fig. 3.

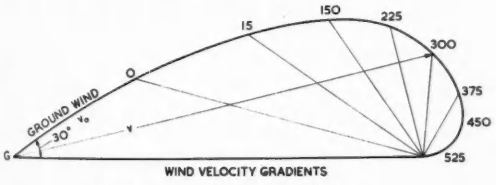

Fig. 3. **Ekman's Wind Spiral.**

Thus, for example, to determine the wind conditions at 300 m height, point G is connected with the point of the spiral marked 300. The vector thus obtained is about 2·75 times greater than the wind velocity v at 10 m height. Its deviation is about 20 deg. The probable wind velocity v at any height to above ground, can be based on the ground wind velocity v_0 (at level h_0). The empirical formula of Hellerman is then :

$$v = v_0 (h/h_0)^a$$

The value a varies between 0·2 and 0·4. For built-up town areas, $a = 0{\cdot}33h$; for hilly terrain, owing to increased turbulence, higher values should be used, while for flat country lower values are applicable. For example, with $a = 0{\cdot}2$, and $h_0 = 10$ m, $v = 0{\cdot}63\ v_0 (h/10)^{0{\cdot}2}$

For $h = 30$ m, $v/v_0 = 1{\cdot}25$; for $h = 50$ m, $v/v_0 = 1{\cdot}40$; and for $h = 100$ m, $v/v_0 = 1{\cdot}50$. For greater heights, an initial wind velocity of 10 to 16 m/sec should be assumed.

Actual wind velocities are subject to continuous and rapid changes, as the normal state of the atmosphere is turbulent. Even a 1 m thick layer of air, with a barely measurable wind velocity of 1 m/sec, has a Reynolds number of

$$Re = 0{\cdot}1/(15 \times 10^{-6}) > 6600.$$

The critical Reynolds number can be of the order of 2,000, and only in exceptional cases does it reach the value of 20,000. Thus, there is no laminar flow in the free atmosphere.

Wind Strength and Turbulent Viscosity of Air. For the determination of fly - ash paths, it is assumed, *inter alia*, that the transition from the static to the agitated state of viscosity of the atmosphere takes place with great violence, and that the process of the sinking of particles due to gravity is an interrupted one, as they sink during the period of static viscosity, and remain suspended during the agitated period of the atmosphere. The measure of the dependence of virtual viscosity of air on height and wind velocity is shown in Figs. 4 and 5 respectively.

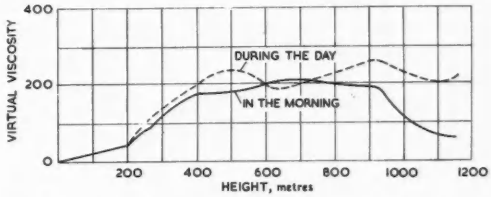

Fig. 4. **Virtual viscosity of air as a function of height**

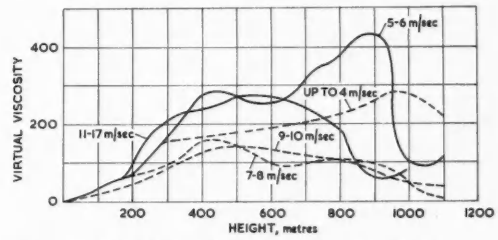

Fig. 5. **Virtual viscosity of air and wind velocity.**

Air Pollution and Wind Velocity. An example of the effect of wind velocity on the concentration of obnoxious constituents in smoke, is given in Table II.

TABLE II. CONCENTRATION OF OBNOXIOUS CONSTITUENTS OF SMOKE, DEPENDING ON WIND VELOCITY.

Wind velocity m/sec	mg/m³ air						
	Carbon monoxide CO	Sulphur dioxide SO_2	Methane CH_4	Dust	Ash	Phosphorous pentoxide P_2O_5	Arsenic pentoxide As_2O_5
1	62·5	1·7	1·3	22·8	2·7	0·340	0·170
1·5	19·1	0·7	0·3	5·5	13·0	0·070	0·036
2	6·9	0·3	0·1	2·2	4·8	0·024	0·012
3	2·5	0·1	0	1·1	1·6	0·008	0·004
4	1·3	0	0	0·7	0·7	0·004	0·002

This example refers to a large steel works adjoining a built-up town area extending over a radius of nearly 4 miles. The steel works and other industries are situated

at the town's western edge, and the wind, for 22 days per year, blows in a westerly direction. The following is a list of the sources of air pollution, with details of annual production: Four blast furnaces, producing 410,000 tons of pig iron; a coke plant, producing 1·6 million tons, consuming 2·3 million tons of coal per year; a chemical plant, 23,000 tons of benzol; a rolling mill, 14,000 tons; three Siemens furnaces, 750,000 tons; rolled steel, 215,000 tons; ten Siemens-Martin furnaces, 1·4 million tons of steel; a power station, burning pulverised coal, for 100,000 kW/year; and a brick and cement works, 125,000 tons.

Table II gives the concentrations of the various constituents of the smoke discharged by these industries, measured in the part of the town nearest to the industrial site. The mean values of concentration are given in mg/m³ air, and would be reduced to 60 per cent in the centre of the town, and to only 30 per cent in the eastern zone. In the Table, all concentrations exceeding the allowable limits are in italics.

From the point of view of hygiene, smoke at a wind velocity of 4 m/sec and above does not constitute a danger. However, dust and fly-ashes at wind velocities up to 2 m/sec are so considerable that the town is at times blacked out, and visibility is reduced to a few hundred metres, whereby ultra-violet radiation is fully absorbed and daylight 50 per cent absorbed. With normal meteorological expectations, these conditions prevail for 1½ days per year.

The maximum concentration of carbon monoxide is 62·5 mg/m³ in the western part of the town, 37 in the centre, and 19 in the eastern part. The maximum concentration of dust and ashes in the west of the town can reach 25 mg/m³.

Such high concentrations are sometimes measured in Charkov. They are 75 times greater than the permissible limit, which is recommended as 0·3 mg/m³. Dust deposits in the western town districts are about 3,750 tons per square mile per year, or more than five times the amount registered in Leningrad.

RUSSIA

Vibration Damper for Metal Cutting

By D. I. RYZHKOV. (From *Stanki i Instrument*, No. 3, 1953, pp. 23-24, 6 illustrations).

VIBRATIONS, usually known as "tool chatter," have many detrimental effects in metal cutting, and arise from the cutting process itself. The number of factors which determine the occurrence and nature of tool chatter is so large that, in view of the great diversity of turning work, measures for the suppression of tool chatter under shop conditions are difficult to administer.

A vibration damper or absorber applied directly to the tool holder should greatly facilitate the suppression of tool chatter under the most varying conditions. Such a vibration damper, developed by the author, works on the impact principle (see THE ENGINEERS' DIGEST, Jan. 1953, p. 31) and is shown in Fig. 1. It consists of a bolt (1), a sleeve (2), a spring (3), and a cup (4). This unit is placed near the working end of the tool holder or even on the tool bit itself, and can point in any direction, including vertical and horizontal, the most convenient position being that shown in Fig. 2.

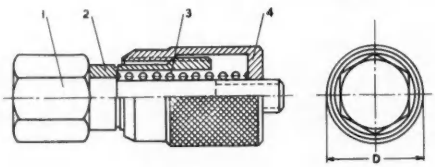

Fig. 1.

The damper is attached to the tool holder either by means of a clamp or an adaptor. Tool holders with welded-on tool bits can be provided with a tapped hole to receive the bolt of the damper. Tool holders with a clamped tool bit can be designed with a tapped hole in the head of the clamping bolt.

The device functions as follows: The cup, loaded by the spring, is a vibrating system and, at a certain combination of cup mass and spring preload, is tuned to the frequency of vibration of the tool holder. At resonance, the motion of the cup is in exact opposition to the motion of the tool holder and the cup becomes a dynamic vibration absorber, since the impact of the cup against the tool holder absorbs the energy of vibration. It has been found that, when the bolt is fairly loose in the tapping, its own mass, vibrating within the clearance of the thread, helps in the absorption. The practical effect is to increase the range of frequencies to which the absorber is tuned.

This absorber has been tried in a number of set-ups in turning and has been found to reduce substantially some of the detrimental effects of tool chatter, such as premature and uneven loss of sharpness of the cutting edge and bad surface quality of the machined component.

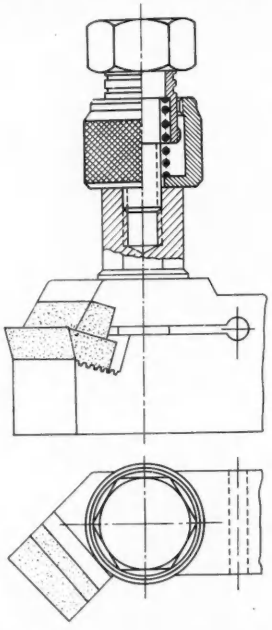

Fig. 2

Five standard sizes of vibration absorber have been found sufficient to cure tool chatter in all turning operations encountered in production. It is pointed out in particular that this vibration absorber has made it possible to use sintered alumina tool bits under conditions in which otherwise these bits would either be fractured or would suffer rapid wear of the cutting edge.

Periodic Mechanisms with Steel Tape or Chain

By K. HAIN. (From *VDI-Zeitschrift*, Vol. 95, No. 6, February 21, 1953, pp. 192-196, 16 illustrations.)

IN kinematics, a steel tape, rope, or chain which rolls on a circular or arbitrarily curved cylindrical disc replaces two simple connecting links in a mechanism. The relative motion between tape and disc is assumed to consist of pure rolling without slip, since friction is not used for the transmission of forces; if the mechanism can be so arranged that a certain part of the tape always remains in contact with the disc, then tape and disc may be connected rigidly, so that slip is impossible. Since contact between the two components occurs over a surface, wear is practically absent, even for relatively large transmitted loads. In periodic mechanisms the velocity ratio of driving and driven member varies continuously and is repeated periodically when the driving crank rotates uniformly. Since the tape can only transmit forces in tension, it must itself always be tensioned either by external forces acting on driver and follower or by arrangement of another tensioning tape.

Tape mechanisms are very accurate and work entirely without play; they are therefore favoured in the design of instruments and scales. The rolling movement between tape and circular disc necessarily generates an involute, so that tapes are often used for gear cutting machinery. Moreover, tape mechanisms can be produced very cheaply and are easily adjustable, hence their use in agricultural machinery where the disc is frequently a rough cast unmachined component. Finally, tapes need no lubrication or other special attention.

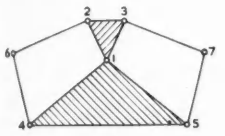

Fig. 1

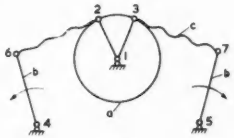

Fig. 2

Fig. 1. **Watt's six-bar chain with lower pairs.**

Fig. 2. **Mechanism with steel tape derived from Watt's mechanism.**
a = Rolling disc, *b* = rotating links, *c* = steel tape.

Different forms of tape mechanisms can be derived from ordinary kinematic chains with lower pairs. For instance, Watt's six-bar chain (Fig. 1) leads at once to the tape mechanism in Fig. 2, when the ternary link 1-2-3 is replaced by a disc and the two connecting links 2-6 and 3-7 are replaced by the tape. The fixed points 1-4-5 and moving links 4-6 and 5-7 remain unchanged. The forces required to tension the tape are indicated by the arrows in Fig. 2. The fundamental forms of the six-bar chain and of the tape mechanisms derived from them are summarised in Fig. 3. *A* is Watt's six-bar chain, *B* is Stephenson's six-bar chain; *C* follows from *A*, and likewise from *B*, if the joints 4 and 5 are combined to form a double hinge. The diagrams (*a*) to (*e*) illustrate the fundamental forms of the derived tape mechanisms, diagrams (1) to (13) the various applied forms when three, or only two, points of the mechanisms are fixed in space. Other forms will result if the tape is rolled over a stationary disc or if part of the tape is fixed and the disc rolls along the tape.

For a kinematic analysis of these mechanisms, the curve described by the centre or by other points of the disc must be known. Fig. 4 shows how this curve is found for the simplest arrangement where the ends *A* and *A'* of the tape are fixed; the curves for more complicated arrangements can then be constructed by known methods.

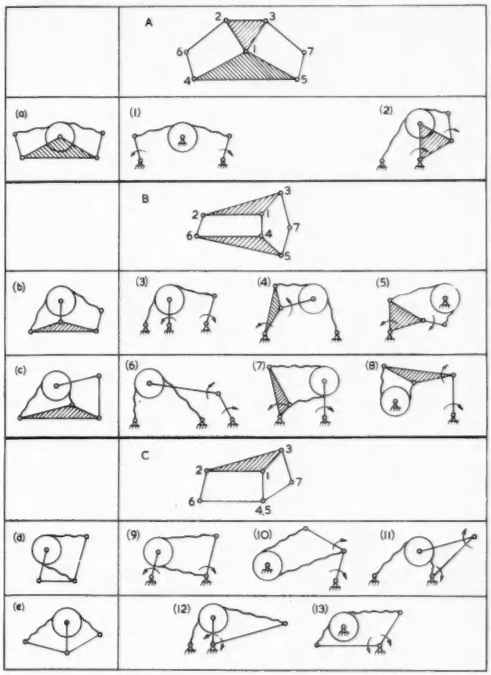

Fig. 3. **Forms of mechanism with steel tape, rolling disc, and two rotating links.**

Let *B* be the centre of the disc in a known initial position. It is first assumed that *B* is fixed and the disc *a* stationary while the tape rolls on the disc without sliding. The ends *A* and *A'* then move to the points A_2 and A_1' along involutes *e* and *e'*, which are easily found by known methods; owing to this involute motion, however, the distance AA' or A_1A_1' must remain constant for every position of the tape, so that if A_1 is assumed, A_1' can always be found. The construction of a triangle AB_1A' equal to A_1BA_1' establishes point B_1 on the actual curve described by *B* when *A* and *A'* are fixed in space. If the tape is long enough, the disc may revolve along a closed curve, provided the ends of the tape are hinged and sufficient space is available for the tape to pass in between the trunnion bearings *A* and *A'*. The various curves *b*,

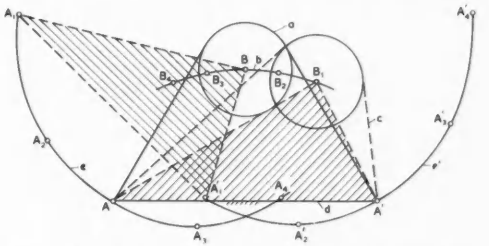

Fig. 4. **Construction of curve described by the centre of a circular disc rolling inside a steel tape with fixed ends.**
a = Disc, *b* = curve described by centre *B*, *c* = tape, *d* = fixed frame, *e*, *e'* = involutes.

possible with different lengths of tape, are symmetrical about the axis AA' but are not symmetrical about the axis normal to AA'.

The two parts of the tape may also roll on different concentric circles of the disc; the tape then usually consists of two separate portions fastened rigidly to the respective circumferences at points which leave sufficient length for the maximum rolling movement. In this case, the construction of curves b is similar to that shown in Fig. 4, but the curves are, in addition, unsymmetrical about the axis AA'.

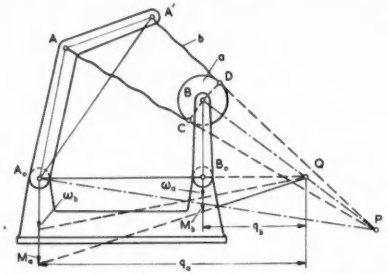

Fig. 5. **Mechanism with tape, simple circular rolling disc, and two fixed pivots.**
a = Disc, b = tape, ω_a, ω_b = vectors of velocity, M_a, M_b = vectors of torque.

As an example showing various possibilities of applying these mechanisms, consider the special type (7) in Fig. 3 and illustrated more fully in Fig. 5. The kinematic relationships follow immediately from a similar six-bar chain with lower pairs: the projected lines formed by the unsupported lengths of the tape intersect in the point P; the line $A_0 B_0$, connecting the two fixed centres of the mechanism, intersects PB in the centre Q, which determines the instantaneous velocity ratio of the driving crank BB_0 and the follower $A'AA_0$, viz.,

$$i = \frac{Q\,A_0}{Q\,B_0} = \frac{q_a}{q_b} = \frac{M_a}{M_b} = \frac{\omega_b}{\omega_a}, \quad \text{(see Fig. 5)}$$

where M_b and M_a are the driving and transmitted torque, w_b and w_a the angular velocities of driver and follower, respectively. Since driving and transmitted torque act in opposite senses and the tape must always be in tension, the mechanism will work correctly only when the crank BB_0 has a clockwise rotation. The same kinematic analysis is valid if the two parts of the tape roll on different concentric circles of the disc or if the circumference of the disc is a curve of arbitrary shape. Where the velocity ratio i is important, the tape should be fixed to the disc, so that no slip can possibly occur.

The cam or slot mechanisms equivalent to a given tape mechanism are easily found. If, for instance, it is assumed that the follower $A'AA_0$ of Fig. 5 is held stationary and the link BB_0 disconnected, then the centre B of the disc describes a curve which can be constructed from Fig. 4. If, on the other hand, the link $A'AA_0$, together with the tape and disc, is replaced by a slotted lever and if point B moves inside the slot, which has the form of the curve just found, then the resulting slot mechanism (Fig. 6) is equivalent to, and thus replaces, the tape mechanism of Fig. 5. The slotted lever exactly repeats the motion of link $A'AA_0$. Similarly, the point B may be assumed stationary, the joint A_0 disconnected and the curve then described by A_0 on $A'AA_0$ used to determine the form of the slot in a lever hinged at B. In the resulting slot mechanism, this lever again replaces tape, disc, and link $A'AA_0$, but now simulates the motion of the disc a. The task of designing a tape mechanism for a prescribed motion is therefore simplified if the corresponding slot mechanism, which will supply the desired motion and which is to be replaced by the equivalent tape mechanism, is first determined.

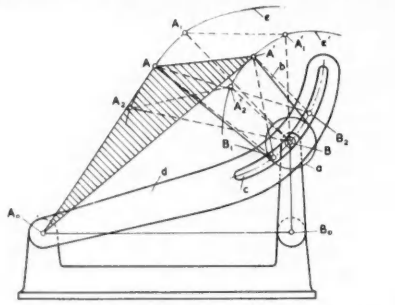

Fig. 6. **Substitute slot mechanism for the tape mechanism shown in Fig. 5.**
a = Rolling disc, b = steel tape, c = curved centre line of slot, d = slotted lever, e, e' = involutes.

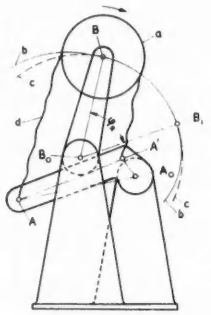

Fig. 7. **Tape mechanism of Fig. 5 designed as a revolving mechanism with a period of rest of the follower.**
a = Rolling disc, b = curve described by centre B of disc a, c = circular arc of radius $B_0 B$, d = tape, φ_R = angle determining the period of rest of the follower.

Fig. 7 shows a variant of Fig. 5. The driving crank BB_0 revolves uniformly and the follower $AA'A_0$ also revolves but has a period of rest while BB_0 turns through the angle φ_R. This period of rest is constructed as follows: the curve b described by B for stationary tape ends A and A' is approximated by a circle c of radius BB_0, so chosen that c coincides with b along the arc BB_1 subtending φ_R; beyond B, the circle c continues inside the curve b, beyond B_1 it continues outside b. The pivot A_0 is also chosen according to certain rules. The crank BB_0 must revolve in a clockwise sense, and the follower $AA'A_0$ must be subject to an anti-clockwise torque, so that the tape is always held in tension.

Tape mechanisms can be designed to execute complicated motions at relatively low cost. The seven hinged joints of the six-bar chain with lower pairs need careful lining up for ease and accuracy of the movement, but the steel tape is able to compensate relatively large inaccuracies in the mounting of the three hinges (e.g., A_0, B_0, B in Fig. 5) and the hinged ends of the tape. Such inaccuracies do not seriously affect the precision of the motion of a tape mechanism. In fact, since the axes of the pivots A_0 and B_0 of driver and follower can now be placed at an angle, the possibility of developing cheap three-dimensional mechanisms is indicated. The exact motion of the tape mechanism can easily be adjusted by a change in the active length of the tape. The arrangement of arbitrarily curved rolling discs and the addition of further contact curves impart an extraordinary adaptability to these mechanisms.

Properties and Applications of Electrically Conductive Rubber

By P. O'Keefe. (From *Materials & Methods*, Vol. 37, No. 4, April 1953, pp. 96-97, 3 illustrations.)

All types of natural and synthetic rubber can be processed so as to be electrically conductive. Although, at present, the principal application of conductive rubber is in the dissipation of static electricity, many new applications are being discovered, some of the most interesting being in the field of electronics and electro-acoustics.

Conductive rubber is made with specially processed carbon blacks, lamp blacks, and acetylene carbon blacks, the latter being used for the most conductive varieties. In non-conducting rubbers, the reinforcing carbon is well dispersed in small clusters, but although the carbon itself is a good conductor, the clusters are scattered and there are no continuous paths to carry electric currents. The special blacks used in conductive rubbers, on the other hand, show strong interparticle forces and tend to form long chain-like clusters in the rubber. These carbon chains carry electric currents, lowering the resistivity of the compound.

All types of natural and synthetic rubber and rubber cements can be made conductive. Sheet, film, filament, and wire are available in low-resistivity (1 to 5 ohm-cm) forms. Also, sheet, film, filaments, wire, and moulded products are made with resistivities from 10 to 10^6 ohm-cm.

Conductivity increases with the amount of carbon black added. However, increasing the carbon black content also effects other properties. It increases hardness, reduces elongation, and increases tensile strength up to a point of maximum reinforcement, beyond which more carbon black reduces tensile strength. With some synthetic rubbers, increased conductivity does not necessarily mean lower strength. The general rule, nevertheless, is that conductive rubbers are not soft, and the higher the conductivity, the harder the rubber.

The electrical resistance of conductive rubbers varies as the material is put under stress, to which it is roughly proportional. Unlike other materials, however, these rubber compounds increase in resistivity in both tension and compression. There is also a time factor involved : The electrical resistance increases as the stress is applied ; under a constant stress, however, the resistance slowly decreases again and does not return to its original value immediately after the deflection is released. Continued flexing tends to increase the resistivity. This may not be true, however, when the deflection is kept below a given limiting value, depending on the particular rubber used.

Temperature and chemical environment also affect the performance of conductive rubber. The useful life of any rubber is lowered at high temperatures, due to oxidation. Conductive rubbers are no exceptions to this rule. The life of a conductive rubber at an elevated temperature will be exactly the same as that of a comparable non-conductive rubber at the same temperature. Conductive rubbers are also affected by substances which cause swelling. This swelling is accompanied by an increase in resistivity, though the original conductance may be restored by drying out the material.

One use of conductive rubber moulded parts, film, and sheet is to dissipate static electricity. Resistivities used range from 10^2 to 10^6 ohm-cm. Resistivity tolerances can be wide. Since the small static charges built up by friction are at high voltage, a highly conductive path to earth is not necessary and variations in the resistivity of the rubber are not important. As examples of the use of conductive rubber in this field, the tyres of aircraft and of vehicles used for the transport of inflammable liquids may be conductive, while conductive rubber ground straps on such vehicles are quieter and wear longer than steel or copper earthing chains. Table tops, containers, transmission belts, conveyor belts, and power materials are used in plants making or handling explosives, inflammable volatile liquids, and dangerous

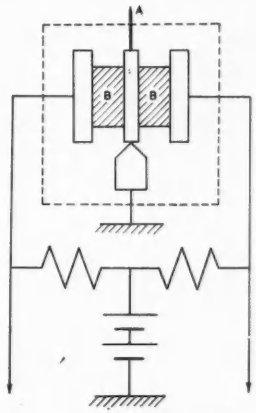

Fig. 1

dusts. In hospital operating rooms, where explosive anaesthetising gases are handled, conductive rubber tubing, bumpers, flooring, and caster wheels prevent sparking. Conductive fabrics filter finely divided dusts and prevent the build-up of static electricity. Rubber-covered rolls handling sensitised photographic paper remove static electricity to prevent fogging of the paper. Sand-blasting hoses can be made of conductive rubber to prevent the build-up of charges that might otherwise puncture the hose walls.

Conductive rubber films and coated fabrics are also used for electric heater elements. The material is embedded in insulation, often non-conductive rubber. Advantages are a uniform distribution of heat over broad areas at moderate temperatures, light weight, moderate space consumption, and the ability to dissipate large amounts of heat (10-12 watts/sq. in.). Wind and rain erosion resistance and wear are better than they are with embedded wire heater pads. Conductive rubber also seems to last longer because there are no local overheated spots. When vibration is present, there is an additional advantage, since resistance wires have relatively low fatigue strengths.

The property, already mentioned, of increase of resistivity with swelling makes the use of conductive rubber seem promising for gasoline leak detection in, for example, aircraft. When gasoline comes into contact with the rubber, the latter expands and the sharp rise in sensitivity can be used to signal a leak.

Some interesting applications of conductive rubber are to be found in the field of electronics.* It is true that considerable research remains to be done in this field, but it is already possible to envisage the eventual production of rubber triodes.

Simple microphones, in which one or two pellets of conductive rubber are held in contact with the centre of a diaphragm, have given excellent results. High-impedance microphones of this type can compete with more conventional types, all the more so by virtue of their extremely low cost of production.

The use of conductive rubber in a gramophone pick-

* The following excerpts from an article by J. Vautier (*S.T.Z. Switzerland*, No. 22, May 28, 1953, pp. 363 & 364, 2 illustrations) have been added.—Editor, E.D.

up is shown in Fig. 1. The movement of the needle A is transmitted to a silver plate held firmly between, and in contact with, two rubber blocks B. The arrangement shown permits modulation of the last stage of an amplifier and can be used directly in push-pull, with elimination of the need for screening and with suppression of paired harmonics. Cost of production is very low, compared with that of similar pick-ups of conventional design.

Another application of conductive rubber, one which is efficient and relatively very cheap, is in speed and voltage-control. In thise case, centrifugal force is made to act on a pair of rubber pellets and the resulting change in resistivity can be used to control speed or voltage.

RUSSIA

Abrasive Liquid Polishing of Hollow Cylinders

By E. A. SATEL, *et al.* (From *Stanki i Instrument*, No. 9, 1952, pp. 26-27, 3 illustrations.)

POLISHING by abrasive liquid is virtually a fine-cutting operation and is performed by a jet of liquid mixed with powdered abrasive and fed to the work by means of compressed air.

Fig. 1 shows in diagrammatic form a machine for performing abrasive liquid polishing simultaneously on two cylinders. One end of each machined cylindrical component is clamped in the carriage (3), leakage of the abrasive liquid being prevented by leather seals. The other end of each cylinder is clamped, also with a seal, in the sliding support (4), which also serves to steady the rotating delivery tubes (5), fitted with nozzles at the delivery end.

An electric motor (9) drives the lead screw (1) through a V-belt and worm gear transmission. The lead screw propels the nut (2) attached to the carriage (3). Reversal of the carriage motion is carried out by reversing the electric motor and by limit switches adjustably mounted on the bed of the machine.

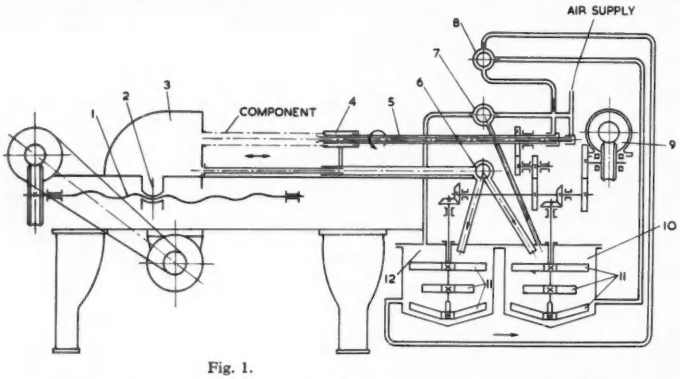

Fig. 1.

Vessels (10) and (12), each of 75 litres capacity, contain abrasive liquid, agitated by mechanical mixers (11) rotating at 115 rpm. These are driven by another electric motor of 2·2 kW through the transmission shown diagrammatically in Fig. 1. The same transmission also rotates the delivery tubes (5) fixed in the spindle-stock of the machine. The drive for the spindle-stock contains change gears which permit variation of spindle speed between 50 and 200 rpm. The abrasive liquid mixing vessels are both connected to the delivery tubes via a three-way cock (8) and a rubber hose. The abrasive liquid circuit is continued through the machined component, and the liquid collects in the carriage, returning to the mixing vessels via a system of telescopic pipes and another three-way cock (6).

Compressed air from the works distribution system is admitted into the mixing vessels at a pressure of between $\frac{1}{2}$ and 1 atmosphere. The pressure is maintained at a constant value by a special pressure regulator. The supply of compressed air can be switched from one mixer to the other by another three-way cock (7). Compressed air is simultaneously supplied to the inner tubes of the delivery tube assemblies and thus serves both to raise the abrasive liquid from the mixing vessels and to force the abrasive liquid through the nozzle to the machined surface.

In order to find the best conditions of operation for polishing with abrasive liquid, tests were carried out on cylinders of between 35 and 45 mm diameter. The rate of advance of the component was varied between 210 and 800 mm/min. A low value of component advance was found to give better results.

In order to direct the jet of abrasive liquid at a definite angle to the machined surface, the delivery nozzle shown in Fig. 2 was used. The wedge (1), liquid nozzle (3), and air nozzle (4) are assembled in the housing (2) of the delivery nozzle unit. The abrasive liquid is fed through the liquid nozzle to the mixing chamber (5), whence it is ejected under pressure through four openings against the machined surface. The direction of the abrasive liquid jet is determined by the contour of the slots in the wedge (1).

The most suitable abrasive liquid has the following composition: Water 64·6 kg; electrocorundum 33·0 kg; sodium carbonate 2·0 kg; sodium nitride 0·4 kg. The ratio between air and liquid consumptions is about 1·1 by weight. The liquid is fed to the delivery tubes under a pressure of about 0·9 atmosphere. The air pressure before entering the air nozzle (4) is of the order of 4 atmospheres.

In machining with liquid abrasive, the removal of metal can be continued indefinitely. However, the surface smoothness reaches an optimum after a certain time and cannot be further improved without altering the particle size of the abrasive suspended in the liquid.

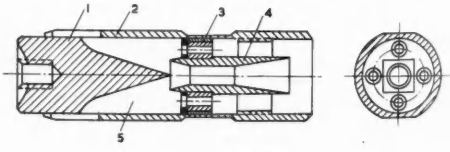

Fig. 2

A weakness of the installation described is the rapid wear of the housing and wedge piece of the nozzle assembly. Made of chrome-nickel steel and heat-treated to a Rockwell C hardness of about 57, these parts were worn away after about 4-5 hours.

Design and Selection of Universal Joints

By E. BORCHERT. (From *Industrie-Anzeiger*, Vol. 75, No. 34, April 28, 1953, pp. 3-7, 21 illustrations.)

It is important for designers and works engineers to know which type of universal joint is most suitable as regards power transmission and efficiency. The basic theory is extensively dealt with in the literature referred to in the bibliography at the end of this article. From the practical point of view, the universal joint should be rigid, both statically and under dynamic load conditions, and should have low frictional losses. These aspects are discussed in the following.

THE term "universal joint" is a comprehensive designation which includes ball-and-socket joints, cross-link joints, and Hooke's or cardan joints, but excludes ball joints of the type used for fittings, electric lamps, etc.

Universal joints serve to transmit rotary motion from an input shaft to an output shaft, with or without an angle between the shaft axes. They are employed in all branches of engineering, and a list of some applications gives an idea of their versatility:—Drives of drilling spindles in multi-spindle machines; table drives in machine tools; steering and braking devices for road vehicles and aircraft; furnace-feeding systems for steam boilers; brush drives in street-cleaning machines; printing machines; automatic presses; paper-cutting machines; wood-working machines; agricultural equipment; machines for the tobacco and textile industries; electrical engineering equipment; testing and calculating machines; astronomical instruments; sound-film equipment.

Universal joints are also used for shaft connections which may have alignment errors owing to the manner in which the shafts are set up. An example is the drive for drilling shafts used in drilling equipment. In this application, universal joints are employed to avoid any effects of misalignment of the driving spindle on the drilling head, since any "forcing" of the latter would result in inaccurate drilling.

Universal joints may be divided into two basically different classes, *viz.*, pivoted joints and sliding joints. Pivoted joints have two pairs of pivots at right angles, fitted in corresponding recesses of a coupling member, whereas sliding joints generally have forked ends or jewels sliding in corresponding grooves.

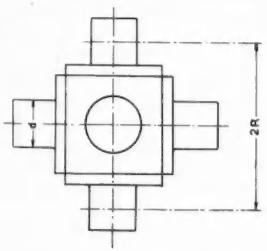

Fig. 1

According to Reuthe, the frictional losses depend on the ratio $d/(2R)$, where d = pivot diameter and $2R$ = centre distance of applied forces (see Fig. 1). Therefore, it can be stated that the efficiency of universal joints is improved by using small diameter pivots and long arms for the power transmission.

Reuthe's investigations show that the frictional losses of sliding joints are about three times greater than those of a corresponding pivoted joint. This eliminates the use of sliding joints in high-performance applications, and the object of investigation is, therefore, to determine those types of pivoted joints which give optimum efficiency.

Fow low frictional losses, it is necessary that the coupling member and its pivots should form an accurate geometric arrangement. Originally, the coupling member was of spherical shape, with holes or recesses provided for the insertion of the pivots, which were parts of the forked ends. However, as shown in Fig. 2, the

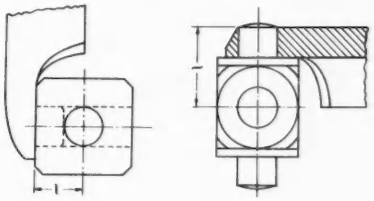

Fig. 2

length l of the lever arm in such an arrangement is very small and accurate fitting is very difficult for mass production, so that with spherical coupling members it is doubtful whether geometrical accuracy can be attained.

When, as a result of the investigations of Kutzbach and Reuthe, it was realized that the power transmission capacity of a universal joint is determined by the length of its power-transmitting arms, the pivot recesses were shifted to positions outside the sphere. The sphere was again provided with cross holes and the arrangement included a cross pin, two bearing sleeves and a rivet pin, as shown in Fig. 3.

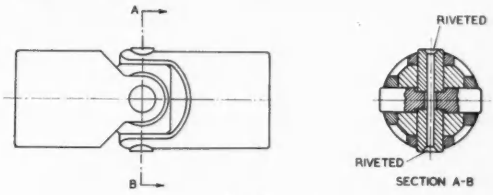

Fig. 3

Mass production of precision components of this type did not find wide acceptance with manufacturers, and endeavours were made to develop more suitable designs. Modern universal joints show a radical departure from the spherical shape for the coupling member, which is now designed, as shown in Fig. 4,

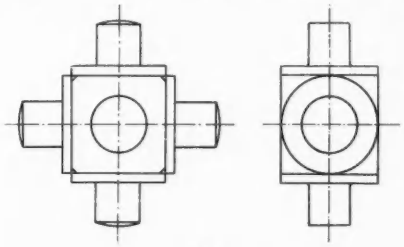

Fig. 4

with geometrical accuracy ensured by suitable tolerances for mass production. The pivoting elements are made of case-hardening chromium steel and machined from the solid. The centering of the pivots is by means of a drilling arrangement with a very large diameter pitch circle (Fig. 5). The large ratio of the pitch circle radius L to the pivot radius l makes possible an accurate production of the cross axes. The pivots and the

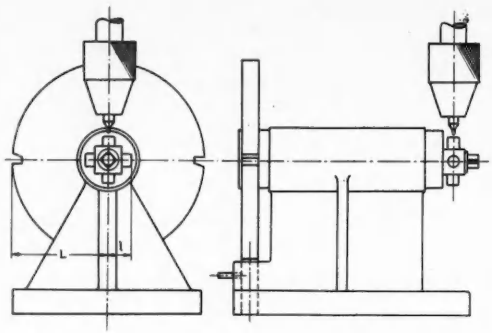

Fig. 5.

adjacent flats are machined between centres, and after hardening the pivot diameters are ground between centres to the required size. The flats are ground, using the arrangement in Fig. 6, and simultaneously checked with a dial gauge to ensure that the required tolerances are maintained. Dial gauge readings of the cylindrical body are then taken with the workpiece between centres, to verify that the pivot body is fully symmetrical and geometrically accurate. However, as the cylindrical guides of the split pins are very short and

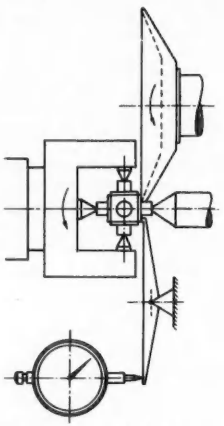

Fig. 6

the spreading out occurring during assembly is frequently not symmetrical, the cross axes may not remain accurate, and this contributes to the frictional losses.

Each pivot supports a fork end of the linkage, made of special high-carbon steel (Fig. 7). Axial motion of the fork elements is prevented by two sunk keys and a seamless steel hub is drawn with a pressure-fit over the assembled semi-cylindrical portions of the fork elements. The forks are spring-hardened to obtain adequate elasticity under impact loads. After hardening, the pivot holes are machined to the required tolerance and the bearing surfaces are ground to size on special machines, so as to obtain a smoothly-operating universal joint, free from excessive play effects. The hub recesses are fine-machined, to avoid tapered openings caused by rubbing.

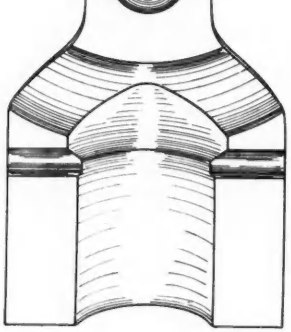

Fig. 7

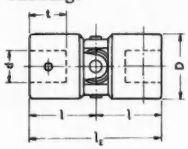

Fig. 8a

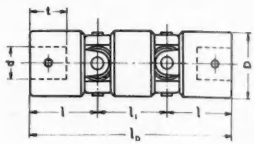

Fig. 8b

Fig. 8c

TABLE I. DIMENSIONS OF SINGLE AND DOUBLE UNIVERSAL JOINTS, as shown in Figs. 8a, 8b and 8c.

Dimensions in millimetres. d = inner diameter of hub ; D = outer diameter of hub ; l_E = overall length ; l_D = overall length of double joint system ; l = length from hub end to fork centre ; l_1 = centre-to-centre length of intermediate portion ; t = depth of hub recess ; d_1, d_2, b, and t_1 = dimensions of special types with square, hexagonal, and keyed sections, as shown in Fig. 8c.

Standard types							Special types		
d	D	l_E	l_D	l	l_1	t	d_1	d_2	$b \times t_1$
6	14	34	—	17	—	9	—	—	—
10	18	50	—	25	—	13	9	10	3 × 1·3
14	28	60	94	30	34	17	12	14	5 × 2·1
18	36	76	116	38	40	22	17	19	6 × 2·5
22	45	92	144	46	52	26	22	22	6 × 2·5
30	55	120	184	60	64	35	30	30	8 × 2·9
40	72	145	225	72·5	80	42	36	36	12 × 3·1
50	90	200	315	100	115	56	46	46	14 × 3·5

Finally, the universal joint is tested as regards rotational accuracy, both in the straight position and when the shafts have an operating angle. Dial gauges are placed both on the hubs and the extension shafts connected to them, and in these tests errors due to out-of-true running conditions should not be above 0·03-0·05 mm for the straight arrangement, and 0·05-0·10 mm for the bent arrangement, according to the size of the joint. Universal joints produced in this manner have an efficiency of 98·5 per cent.

The "Natco" type universal joints, made in the United States, also have a pivot body machined from the solid. However, these joints are of considerable length, owing to the arrangement of the forks and hub recesses.

Generally, universal joints are connected to corresponding shafts by means of taper pins, preferably made of tool steel. However, fitting can also be effected by means of square, hexagonal or keyed sections (see Fig. 8c), using the sizes and dimensions set out in Table 1.

Single joints, with an operating angle of up to 45 deg. have the disadvantage of transmitting as a non-uniform rotation the uniform motion of the input shaft. The driven shaft thus has a cyclic speed variation, which increases with the operating angle. Single joints, therefore, can be used only where this non-uniformity of rotary motion is acceptable.

In practical applications, uniform rotary motion is transmitted by arranging two universal joints coupled in series, in such a way that the accelerations of the first unit are compensated by simultaneous retardations of the second. Manufacturing inaccuracies and errors due to assembling are not, however, cancelled out.

Consequently, although single joints are coupled together in cardan-shafts and similar arrangements, in practice it is preferable to produce the two universal joints as a single unit (see Figs. 8a and b). This arrangement allows operating angles of up to 90 deg. Corresponding numerical data are also included in Table I.

Another frequently used application is that of universal-jointed shafts allowing axial adjustments of shaft length (see Fig. 9). The basic dimensions for the components are given in Table II, but the lengths of the connecting sleeves and the intermediate shaft depend on each particular problem under consideration.

When fitting universal-jointed shafts, in order to obtain uniform motion, there are certain rules which should be carefully observed in assembling, *viz.*: (i) The operating angles α and β (Fig. 9) of the input and output shafts, relative to the intermediate shaft, should be equal. (ii) The input and output shafts should follow the same direction, i.e., they should be parallel to one another. (iii) The maximum value for α or β is 45 deg.

As modern engineering applications frequently operate at high running speeds, it is desirable to ensure that the system is properly balanced. Instead of using one key, as shown in Fig. 9, it is therefore preferable to use two keys in positions 180 deg. apart on the shaft periphery. Particularly at high speeds, balancing should be adequate and the shafts should be supported close to the joints, so that in this respect short joint lengths are an advantage.

Lubrication at high speeds is particularly important. For low speeds, the oil grooves normally provided in the fork ends are sufficient. At high speeds, it is advisable to employ a flexible oil jacket with an annular chamber or recess, designed as a single-fold bellows. This serves both as a lubricating chamber and a protection against dust. The flexible sleeve with the bellows is pulled over the joint with suitable tension by means of spreading rings. If space restriction prevents the use of this arrangement, it is possible to re-design the cavity in the pivot block for use as an oil chamber, with small oil holes through the metal to the adjoining flat surfaces, the oil being thus forced out by centrifugal action.

Generally, universal joints are designed with a certain amount of play, so that a strong film of lubricant may be formed. For controlling devices, however, in which even the slightest play is undesirable, tight-

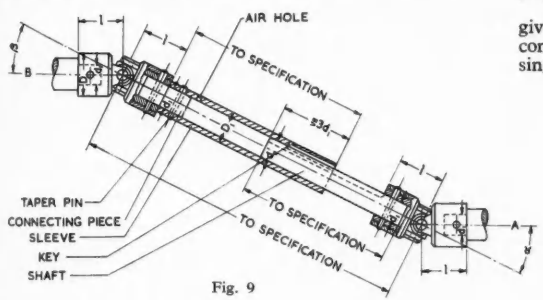

Fig. 9

TABLE II. DIMENSIONS IN MM. OF DOUBLE JOINTS ALLOWING AXIAL ADJUSTMENTS, as shown in Fig. 9.

$d_1 \times D$	l	D_1	Taper pins	
			one	two
10 × 18	25	16	3 × 16	3 × 18
14 × 28	30	22	5 × 22	5 × 28
18 × 36	38	28	5 × 28	5 × 36
22 × 45	46	32	6 × 32	6 × 45
30 × 55	60	40	8 × 40	8 × 55
40 × 72	72·5	60	10 × 60	10 × 72
50 × 90	100	70	13 × 70	13 × 90

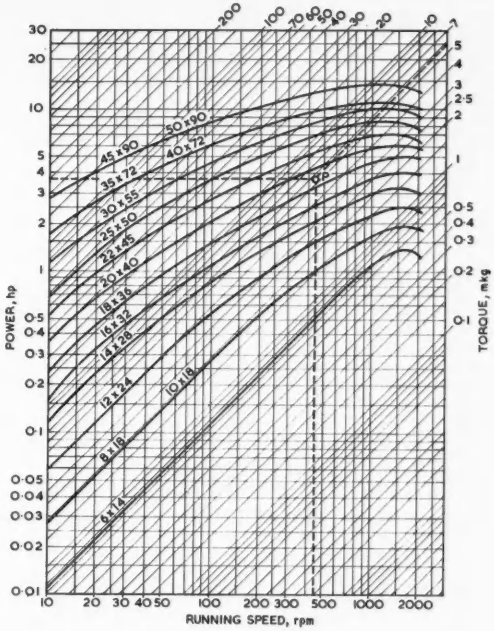

Fig. 10

running universal joints are produced.

An illustration of the degree of accuracy with which such universal joints can be produced is given in the following example, taken from actual practice. A universal joint, with a 6 mm hub recess (see Table I) and with a play not exceeding 0·834 deg after a number of hours of continuous running was required. The components provided by the makers were tried out by the users on their own test rig. After 70 hours continuous running at 750 rpm, followed by 10 hours at 1200 rpm, the universal-jointed shaft was found to have a rotary play of only 0·083 deg.

The values indicated in the power rating diagram given in Fig. 10 represent maximum permissible load conditions for an operating angle of up to 10 deg. for a single joint, with adequate lubrication. After several

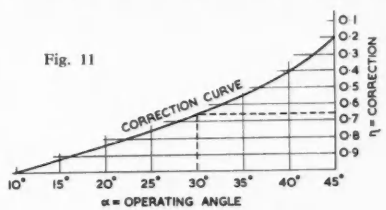

Fig. 11

hours operation under load, the temperature of the joint should not exceed 75° C. If the joint or joints are immersed in an oil bath, the permissible load value can be taken as 10 per cent higher than the value indicated in Fig. 10.

If the required working angle exceeds 10 deg., the pivoting movements, and hence the frictional work produced in the unit, become correspondingly greater. The quantity of heat to be dissipated then makes it necessary to limit the transmitted power to a smaller value. This is obtained from the correction curve in Fig. 11, which indicates as a function of the operating angle the correction to be used in conjunction with Fig. 10.

A numerical example (indicated by dotted lines in both diagrams) will serve to illustrate the procedure.

Numerical example :—It is required to determine the size of a universal joint to transmit 2·5 hp at 450 rpm, with an operating angle of 30 deg.

The procedure is as follows :—

1. Follow in Fig. 11 the dotted line perpendicular to the base-line at $\alpha = 30$ deg. It intersects the correction curve at a value $\eta = 0{\cdot}65$.
2. The equivalent power-capacity value to be used in Fig. 10 is therefore

$$\frac{\text{required power}}{\text{correction}} = \frac{2{\cdot}5}{0{\cdot}65} = 3{\cdot}85 \text{ hp.}$$

3. Referring to Fig. 10, follow the dotted line perpendicular to the base-line at $n = 450$ rpm, to the height corresponding to 3·85 hp on the left-hand scale. The point of intersection P of the dotted lines determines the size of the universal joint, which is taken from the oblique curve situated immediately above the intersection.
4. The chosen values are therefore : 20 × 40 mm.

If, instead of the transmitted power in hp, the loading is expressed in terms of the transmitted torque in mkg, the procedure for evaluation remains the same, except that the vertical line for the rpm is considered in conjunction with the diagonal lines representing torque values, which are indicated on the scale on the right-hand side of the diagram in Fig. 10.

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HOLLAND

Optical Image Formation without Lenses or Mirrors

By A. C. S. van HEEL. (From *De Ingenieur*, Vol. 65, No. 24, June 12, 1953, pp. 25-27, 9 illustrations).

THE normal purpose of an optical image reproducing system is to transmit the details of an object in one plane to another plane, with as much detail and contrast as possible. The usual system of lenses or mirrors (or a combination of both) must be set to close tolerances and the arrangement must be correctly centered with respect to its axis of symmetry, to avoid disturbing aberrations. Only flat surfaces are capable of reproducing images without aberration. With flat mirrors, however, either the object or the image is " virtual." A plane mirror cannot form a real image from a real object.

The representation of a real object by means of a real image is a requirement frequently occurring in practice. It can be fulfilled by means of the image-transmitting elements described below, which are, in addition, free from aberration effects or centering limitations, although the image produced is full size only.

The method employed for image representation is as follows :—The light is conducted through a number of cylindrical rods or tubes of glass or other suitable material. These elements are either in direct contact with air or coated with a material having a lower refractive index than the core material. Any light ray passing through a cross-section of one of these cylinders is thus totally reflected to and from the cylindrical wall surface and after a number of total reflections it emerges through a similar cross-section of the same cylindrical element. Hitherto, this principle has frequently been used in condensers for the illumination of small objects. It should be noted that oblique rays are reflected a greater number of times than rays closer to the perpendicular direction. Furthermore, the quantity of emergent light must still be sufficient to obtain a useful image.

An example of such an element is shown in Fig. 1. It is interesting to note that the element may be bent without affecting its image-carrying properties, provided that the radius of curvature R is not too small. To be more precise, R should be at least ten times the diameter of the cylindrical element. Smooth cylinder walls are, of course, essential ; in fact, their surface roughness should not exceed a certain value depending on the wavelength of the light employed.

If n_1 is the refractive index of the core material and n_2 that of the outer cover or coating, then the angular aperture u, within which total reflection of incident light is ensured, is obtained from

$$\sin u = \sqrt{n_1^2 - n_2^2}$$

If total reflection is ensured for the first incident ray, it is also obtained for all subsequent reflections. To prevent leakage, the thickness of the outer cover must be at least 3 to 5 times the wavelength of the light used.

Fig. 1. **Total reflections of light ray in a flexible image-transfer element.**

It should be mentioned that no useful results can be achieved by coating the cylinder with a reflecting layer, when the length-to-diameter ratio of the cylinder is a large value. The number of reflections is then so great that, even with a very low absorption coefficient such as that of silver, the oblique rays are rapidly extinguished and only a very pointed cone of incident light is effectively admitted. Much better conditions are obtained with the elements described in this article, as these have a much larger angular aperture, and can therefore be regarded as suitable for practical applications.

FLEXIBLE IMAGE-TRANSFER COMPONENTS.

A number of long, thin rods or fibres, coated with a layer of material having a lower refractive index, as previously described, can be combined in the form of a bundle to obtain a flexible unit, which can be used to transmit images from one location to another.

Two arrangements have been considered : (a) Illumination by transmitted light for transparent objects, such as drawings, documents, maps, etc., with a lens system as shown in Fig. 2, and (b) illumination with reflected light for opaque objects, using a light source and a semi-transparent mirror, as indicated in Fig. 3. In both cases, the object is in direct contact with one end surface A of the image-transfer unit. The image formed at the exit surface B can be observed directly on this surface, or it can be transmitted to another position by a lens, which must have a relative aperture sufficiently large to receive the total amount of light emerging from the elements.

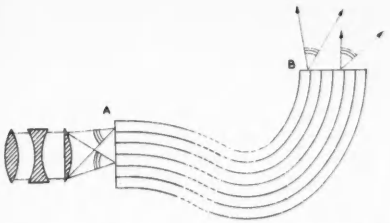


Fig. 2. **Arrangement of illumination for transparent objects.**

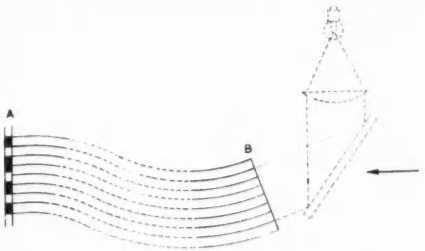


Fig. 3. **Arrangement of illumination for opaque objects.**

As regards definition, it is evident that the smallest detail that can be transferred is of the size of the fibre diameter. In many cases this is no objection, since the fibres can be made much smaller than 1 mm diameter. In fact, it is possible to produce fibres close to 0·01 mm in diameter, in order to make full use of the resolving power of normal photographic material. However, it is hardly permissible to go further, as under such conditions, directional effects and difraction phenomena occur, which are fully analogous to those observed in electronic systems with wave-guides for centimetre waves.

DEVELOPMENT WORK.

The first experiments, begun in January 1950, were made with silver-coated glass fibres. It was immediately found that silvering did not produce good results. Units consisting of uncoated fibres were then tried, with the fibres spaced away from each other, in order to obtain total reflection against air. The mounting of the fibres gave rise to difficulties, so that it was subsequently decided to use elements of the type already described, consisting of a clear plastic core covered with a material having a lower refractive index.

The best results were obtained with fibres of 0·1 to 0·13 mm diameter, covered with a layer a few hundredths of a millimetre in thickness. In addition, an outer coating of black lacquer was applied on the covering layer, to avoid leakage of light from one fibre to another through small irregularities on the fibre surface. In this manner, a very good contrast was obtained in the final image. To obtain a unit which would be fairly rigid and easy to handle, the fibres were assembled in the form of a bundle, with parallel fibres arranged so as to have an approximately circular cross-section, and the assembly was held together by means of putty. The bundle, however, still remains flexible.

The mounting of small fibres one beside the other was still a delicate operation and to simplify this work it was found convenient to wind an adequate length of fibre in successive layers on a cylinder, so as to obtain a coil. The latter was then cut open at one cross-section and given any required shape.

This coil winding method can also be employed with uncoated elements. The fibres of the outer and inner surfaces of the coil are bonded with putty before the coil is cut open. When the unit is straightened, the inner fibres are no longer in contact with each other, so that total reflection against air is obtained. However, after a few experiments with such units, it was found preferable to use the somewhat more rigid units previously described.

With the materials available, it was possible to produce image-transfer components of 20 cm in length. Greater lengths give less favourable image transmission and smaller angular apertures at the exit. If mass-production methods and special manufacturing equipment are used, it is considered that it should be possible to improve considerably on the results so far obtained. Special plastics with a very low absorption capacity could be developed. A further improvement would be to use hollow-fibre elements instead of solid elements, as shown in Fig. 4, where it will be seen that, although any incident ray *a* is partially reflected at *C*, most of the light goes through the material of the hollow core and is totally reflected at *D*. Additional total reflections of the reflected rays occur again at *E* and *F*. An incident ray *b* arriving near the end surface of the material is similarly reflected. Thus, the total quantity of light received is weakened only through absorption in the material of the hollow core. The quantity of light absorbed is only a fraction of the value obtained for a solid core. The value of this fraction is determined by the ratio of the light rays in the air space and in the core material. However, it has not as yet been possible to produce elements of this type with a sufficiently small diameter.

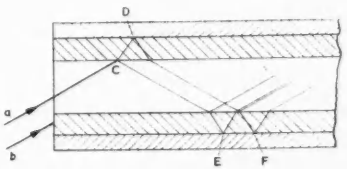


Fig. 4. **Reflection in a hollow-fibre element.**

In the case of one particular solid-core image-transfer component, the materials used for the solid core and the covering layer had refractive indices of 1·52 and 1·47 respectively. The effective aperture angles of the incident and emergent cones of rays were in the ratio of about 1 : 1·8. Transmission efficiency over lengths greater than 10 cm rapidly reached low values (less than 30 per cent), attributable to the absorption coefficient of the material used. Further investigations of the absorption of various materials are being carried out. The unit can be bent to an angle of 180 deg. or even 360 deg. without appreciable effects on the resultant image.

SOME POSSIBLE APPLICATIONS.

Endoscopic equipment, employed for visual examination of internal parts of the human body (e.g. for cystoscopy, bronchoscopy, and gastroscopy), can be fitted with these image-transfer units, with the additional advantage of flexibility. Locations difficult of access can be reached much more easily and with less strain on the patient. This subject is now under study.

Another application, suggested by W. Brouwer, is the use of these elements for the coding of maps, etc. For this purpose, the fibres are wound on a cylinder in an irregular manner, instead of in successive layers. The resultant coil is cut at two cross-sections 180 deg. apart. The two halves of the coil are, therefore, corresponding units. One unit is used for coding, and its output image is photographed. This photograph can be decoded only with the aid of the second corresponding unit, which converts the image into its original pattern.

U. S. A.

Possibility of Error in Poisson's Ratio for Steel

By W. D. MANLEY. (From *The Iron Age*, Vol. 171, No. 17, April 23, 1953, pp. 148-150, 4 illustrations.)

Recent tests indicate that for hot-rolled steel, the modulus of elasticity, the shear modulus, and Poisson's ratio are less than the usually accepted figures. These tests were limited to 18,000 *psi stress. The method might show accepted values at higher levels.*

TESTS were carried out at Oak Ridge National Laboratory (O.R.N.L.), Tennessee, in connection with work on nuclear reactors, to determine with a high degree of accuracy the modulus of elasticity and Poisson's ratio of the reactor metals.

Test specimens were made from ¾ in. dia. hot-rolled 0·2 per cent carbon steel bar stock. The diameter of the section was machined to the root diameter of a ¾ in. thread since the specimen had ten ¾ in. threads on both ends for gripping the specimen on the machine. Four Baldwin SR-4 strain gauges were placed on the specimens and the strain measurements were made with an SR-4 strain gauge indicator and an SR-4 Wheatstone Bridge. Strain readings were taken at intervals of 250 lb load up to a total of 5000 lb, and from these readings the modulus of elasticity and Poisson's ratio were calculated. Six bars were pulled, with calculated average values as given in Table I.

TABLE I. O.R.N.L. TESTS ON STEEL.

Specimen Number	Average Modulus of Elasticity (10^6 psi)	Poisson's Ratio	Calculated Shear Modulus (10^6 psi)
1	28·5	0·235	11·5
2	28·3	0·245	11·3
3	28·2	0·218	11·6
4	29·0	0·243	11·6
5	28·0	0·238	11·5
6	28·3	0·237	11·5
Average	28·4	0·236	11·5

As these results were in contradiction with the accepted value for Poisson's ratio of steel (0·29 to 0·33), and it was possible that the experimental techniques used could be questioned, similar test bars were tested in the metallurgy laboratory at the Nuclear Energy for the Propulsion of Aircraft Project (N.E.P.A.). In this case, an entirely different apparatus was used, and type AX-5 strain gauges were placed on the bars. The values for Poisson's ratio determined at N.E.P.A. (Table II) closely checked those of the original O.R.N.L. tests.

The values of Poisson's ratio obtained from all the six original samples were then plotted as a function of stress, to determine the amount of scatter and to ascertain whether there was any variation of Poisson's ratio as a function of the stress level. It was found that, above a stress level of 4000 psi, the values of Poisson's ratio showed only a slight amount of scatter from there to a stress level of 18,000 psi, the highest value tested.

It was thought possible that the specimen configuration and the way in which the strain gauges were bent around the diameter of the specimen might have caused an error in the original work. Therefore, five large compression samples of hot-rolled 0·2 per cent carbon steel were fabricated. These were 2·02 in. square and 5·05 in. long. Eight SR-4 strain gauges were applied to the compression samples and the specimens were loaded at intervals of 5000 lb up to a total of 80,000 lb, or roughly equivalent to a stress of 18,000 psi. The values for the modulus and Poisson's ratio obtained from these tests are given in Table III.

TABLE III. COMPRESSION TEST RESULTS.

Specimen Number	Modulus (10^6 psi)	Poisson's Ratio
1	30·1	0·259
2	28·1	0·209
3	29·3	0·248
4	30·1	0·257
5	30·4	0·261
Average	29·6	0·247

From these tests it is seen that Poisson's ratio agrees with the values obtained from the tension specimens (Table I). It is unlikely, therefore, that the type of specimen and configuration of the strain gauges can account for this low value of Poisson's ratio.

Finally, as a further check on the experimental technique used, three bars of aluminium were tested in a manner identical with that used on the tensile specimens. Table IV summarises these results, in which the value of Poisson's ratio agrees closely enough with the accepted figure of 0·33.

TABLE IV. ALUMINIUM TENSILE TESTS.

Specimen Number	Modulus (10^6 psi)	Poisson's Ratio
1	10·0	0·324
2	10·0	0·335
3	10·0	0·341
Average	10·0	0·333

CONCLUSIONS

At stresses up to 18,000 psi, Poisson's ratio for hot rolled steel would appear to be between 0·23 and 0·25, and not 0·29 to 0·33, as stated in technical literature. The 0·23-0·25 ratio was found in three different types of tests on a total of 16 specimens; furthermore, the same test method yielded figures for aluminium corresponding closely with those currently accepted in technical literature. Whether this 0·23-0·25 ratio would apply at higher stresses cannot be determined with the test equipment used to fix the new lower range.

TABLE II. N.E.P.A. TESTS ON STEEL.

	TENSION		COMPRESSION			TENSION		
	Loading		Loading			Loading		
Specimen Number	1	2	1	2	3	1	2	3
1. Modulus (10^6 psi)	30·3	30·3	30·5	30·5	30·5	30·1	30·3	29·9
1. Poisson's ratio	0·231	0·258	0·217	0·179	0·218	0·227	0·225	0·208
3. Modulus (10^6 psi)	30·3	....	30·7	....	....	30·0	30·1	30·4
3. Poisson's ratio	0·227	....	0·224	....	....	0·242	0·236	0·232
4. Modulus (10^6 psi)	31·7	32·0	31·4	31·8	....	29·7	30·4	30·4
4. Poisson's ratio	0·200	0·231	0·224	0·224	....	0·270	0·230	0·232
5. Modulus (10^6 psi)	30·0	....	32·0	29·8	....	29·4	30·9	30·2
5. Poisson's ratio	0·233	....	0·225	0·227	....	0·226	0·235	0·224

Methods for the Design of Electrical Devices with Non-Linear Dielectrics

By A. E. KAPLYANSKYI. (From *Elektrichestvo*, Nol 1, 1953, pp. 44-48, 9 illustrations.

The majority of dielectrics have small dielectric constants, independent of voltage. The first exception (potassium sodium tartrate), capable of technical use, became known as rochelle salt. The author uses the expression "rochelle-type dielectric," the Russian equivalent of which is widely accepted. Recent developments have produced another class of dielectrics having the same characteristics. These are based on titanium compounds, mainly barium titanate, and are often described as ceramics. In this article, which is confined to a qualitative discussion, the author examines the analogy between ferromagnetic and rochelle-type dielectric properties and shows how devices, for which hitherto only the properties of ferromagnetic materials could be used, can be converted to utilise the properties of non-linear dielectrics.

Since the introduction of ceramic dielectric materials of the barium titanate type, with an exceptionally high dielectric constant, which depends on the electric field strength and on temperature, many further advances have been made in producing complex ceramic dielectrics with a variety of desirable properties. As a result of these improvements, dielectric constants have been increased and dielectric loss angles reduced.

These materials have found an application as "electrets" in several types of electrical equipment. Apart from the use of these new materials in condensers, their non-linear characteristics afford a particular interest compared with the characteristics of ferromagnetic materials.

CHARACTERISTICS OF FERROMAGNETICS.

The non-linear properties of ferromagnetics appear in the complex dependence of the magnetic induction B (or flux density) on the intensity of the magnetic field H. This dependence is known as the hysteresis loop. For simplicity, consider the simple magnetisation curve in Fig. 1 (external lettering). This curve joins the peaks of the hysteresis loops, i.e., the points H_m and B_m of maximum field intensity and flux density.

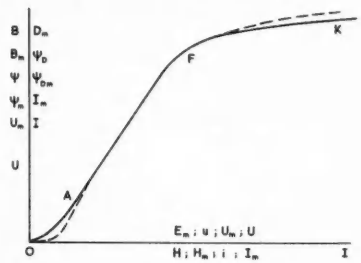


Fig. 1

The same curve on a different scale represents the dependence of the total magnetic flux ψ on the current i in the magnetising winding. Furthermore, it also represents the plot of the amplitude ψ_m of the total flux against the amplitudes I_m of an alternating magnetising current when no d.c. component is present. When the law relating the variation of magnetic flux ψ to frequency ω is sinusoidal, the voltage amplitude across a coil with a ferromagnetic core, ignoring the active resistance of the coil, is

$$U_m = \omega \psi_m.$$

Consequently, the same curve represents the peak voltage-current characteristics $U_m(I_m)$ for a given frequency ω. Owing to the non-linearity of the magnetic characteristics, the current trace with a sinusoidal voltage will not be sinusoidal, but will contain a number of odd harmomic components. For this reason, if we multiply the scale of the ordinate axis by $\sqrt{2}$ to convert it into a scale for the effective (r.m.s.) values U of the voltage, the corresponding points of the r.m.s. value I of the current will not lie on the curve $U_m(I_m)$. The voltage-current characteristics $U(I)$ relating the effective values of voltage and current will be somewhat displaced in comparison with the characteristics relating their peak values.

It is well known that the magnetisation curves contain three typical regions (Fig. 1), *viz.*, the initial range O-A, which is concave in relation to the abscissa axis; the central region A-F which is a straight line; and finally a convex section F-K, which is the saturation range.

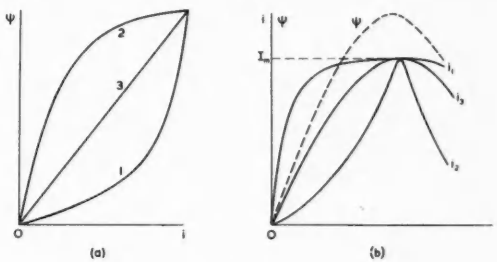


Fig. 2

If the voltage changes only within limits which leave the flux in the initial portion of the magnetisation curve $\psi(i)$ (curve (1) in Fig. 2a), the plot of current i_1 with sinusoidal voltage and flux (Fig. 2b) will be above the sine curve i_3 of the same peak value I_m. The current i_1 will obviously give a larger effective r.m.s. value than the sinusoidal current i_3, so that

$$I_1 > \frac{I_m}{\sqrt{2}}$$

Consequently, the curve $U(I)$ in its initial portion (dotted line in Fig. 1) will be below the curve $U_m(I_m)$.

If the sinusoidal voltage, and hence the flux, vary within wide limits and reach saturation (curve (2) in Fig. 2a) the current trace i_2 will have a sharp top (Fig. 2b) and will be wholly below the sine curve with the same peak value. Its r.m.s. value will be smaller than that of the sine curve, so that

$$I_2 < \frac{I_m}{\sqrt{2}}$$

Consequently, the curve $U(I)$ in the saturation zone will be somewhat above the curve of $U_m(I_m)$ and the saturation effect will be somewhat less pronounced (dotted line in Fig. 1).

In practice, the difference between the r.m.s. curve and the peak curve will be small, because the higher harmonics of current are not only small, but enter into the effective current values with their squares. For this reason the same curve $U(I)$ (Fig. 1) can, with an appropriate scale, serve as the voltage-current characteristics, which will therefore also exhibit the same typical portions, viz., concave, straight, and convex.

In the preceding discussion, a sinusoidal law of

voltage variation has been assumed. A similar result is obtained on the assumption of a sinusoidal current.

In the design of electromagnetic equipment, it is usually not the first concave portion *O-A* which is utilised for its non-linear effect, as it is rather short, but the non-linearity due to saturation, namely the convex portion *F-K* of the voltage-current characteristics. For the sake of generality, both non-linear portions will be considered.

Characteristics of Rochelle Salt Dielectrics.

Rochelle salt dielectrics, and in particular rochelle-type ceramics, are characterised by the relation between the electric displacement D and the electric field strength E. The phenomenon of hysteresis is also encountered in these dielectrics and the relation referred to has the form of a hysteresis loop. If only the basic curve joining the peaks of the hysteresis loops is considered, a curve $D_m(E_m)$ (Fig. 1, internal lettering) is obtained, which has the same characteristic sections, i.e., concave, straight, and convex, as the basic curve of magnetisation.

The curve $D_m(E_m)$ on another scale renders the relation between the electric flux ψ_D (i.e., the flux of the vector D) and the voltage u. Thus, for instance, in a flat condenser with a conductor surface area S and a distance d between conductors :

$$\psi_D = DS \text{ and } u = Ed$$

In other words, the two pairs of magnitudes have a proportional relation between them.

With a.c., the same curve represents the relation between the amplitudes of these quantities $\psi_{Dm}(U_m)$, since the current, in terms of electric flux, is :

$$I_m = \omega \psi_{Dm}$$

and hence the same curve constitutes the current-voltage characteristics between amplitudes $I_m(U_m)$ for a given frequency ω.

In analogy with the coil around a ferromagnetic core, the curve $I_m(U_m)$, in the first approximation, is also the current-voltage characteristics $I(U)$ for the effective (r.m.s.) values of the current and the voltage. At any rate, the effective current-voltage characteristics contain the three typical portions already referred to, namely, concave, straight, and convex.

In making use of the non-linear characteristics of rochelle salt dielectrics, it is necessary to take into account its dielectric strength, which in the present stage of development is not very high. In some cases the danger of a breakdown arises in the region *F-K* (Fig. 1), and it is necessary to limit consideration to the concave portion *O-A* of the curve. It should be emphasised, however, that in rochelle salt dielectrics, the concave part of the curve is much more pronounced than in the magnetisation curve.

It is customary to call a circuit reciprocal to another when the behaviour of the current in one is the same as that of the voltage in the other, and *vice versa*. The coil with a ferrous core is in principle reciprocal with the condenser circuit containing a rochelle " electret," because the voltage-current characteristics of the first is similar to the current-voltage characteristics of the second.

Proposed Method of Design.

In attempting to develop a rochelle " electret " device, analagous to ferromagnetic apparatus, consider the two following cases :

(1) The characteristic curves of the coil and condenser are similar.
(2) The characteristic curves of the coil and condenser are symmetrical.

The first case will be found if the coil is working along the convex part of its voltage-current characteristics but the condenser would be working along the concave part of its current-voltage characteristics. If, instead of the current-voltage characteristics of the condenser, its voltage-current characteristics are taken, by simply turning Fig. 1 through 90 deg., then the concave part of the curve will become convex and the two voltage-current characteristics will become similar. In this case there is clearly no need for any change in the circuit diagram and all that is necessary is to replace its inductive elements by capacitive elements and *vice versa*. In doing so, linear coils will be replaced by linear condensers, and non-linear coils by non-linear condensers and *vice versa*.

A similar position will exist if the working zone of the coil is the concave part of its voltage-current characteristics and the working zone of the condenser is the convex part of its current-voltage characteristics.

In the second case, both devices utilise the same portion of their characteristics. Thus, the coil is working along the convex part of its voltage-current characteristics, and the condenser along the convex part of its current-voltage characteristics. In this case the two circuits must be reciprocal. As is well known, then, in order to obtain a reciprocal circuit, each inductance must be replaced by a capacitance and *vice versa* ; every series connection must be replaced by a parallel connection ; voltage generators must be replaced by current generators and *vice versa*. Active resistances, however, remain unchanged. In such a " reciprocal " rochelle electret device, reciprocal characteristics to the ferromagnetic device will be obtained. Thus, for instance, the ferromagnetic *voltage* stabiliser will become a rochelle electret *current* stabiliser.

Resonance Stabiliser.

A diagram of the simplest ferromagnetic resonance type voltage stabiliser is given in Fig. 3, and its open circuit characteristics in Fig. 4, in which quantities referring to this device are indicated by a single dash. Fig. 4 contains the voltage-current curve $U_c'(I')$ of the linear condenser, which is a straight line, and the curve $U_L'(I')$ of the coil with a ferromagnetic core, which is the magnetisation curve. The sum of the two is the voltage-current curve of the complete circuit. In the right hand part of the graph (beyond the resonance point), a large variation $\Delta U_1'$ of input voltage corresponds to the much smaller variation $\Delta U_2'$ of output voltage.

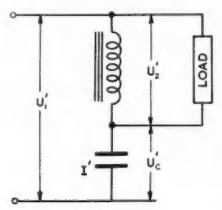


Fig. 3

In this device the convex part of the voltage-current characteristics of the coil is used. To design a stabiliser

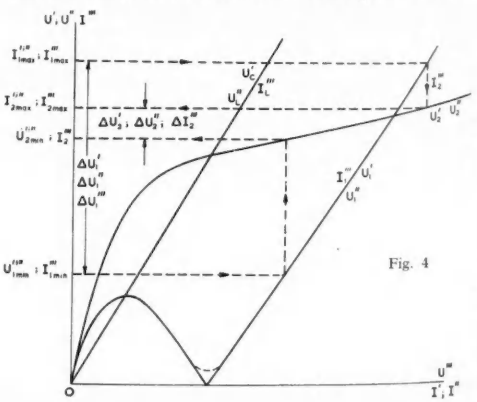


Fig. 4

based on the resonance principle with rochelle-type dielectrics by using the convex part of its voltage-current curve, it is necessary, as indicated above, to replace the linear condenser by a linear coil, and the non-linear coil by a non-linear condenser, as shown in Fig. 5. Such a circuit will continue to function as a voltage stabiliser. Its characteristics will be described by the same graph (Fig. 4), in which the quantities referring to the dielectric device are distinguished by two dashes. Again, as in the ferromagnetic stabiliser, the voltage is stabilised by means of the non-linear element. The difference lies in the fact that the circuit of the electromagnetic resonance stabiliser is a capacity circuit ($U_c' > U_2'$), while the circuit of the dielectric resonance device is predominantly an inductive circuit ($U_L'' > U_2''$).

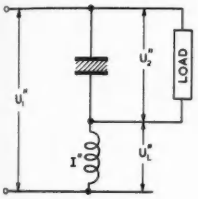


Fig. 5

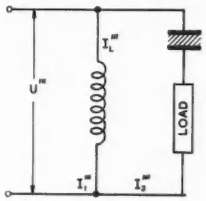


Fig. 6

In utilising the concave part of the voltage-current curve of the dielectric (which could also be called the convex part of its current-voltage characteristics), it is necessary to convert the circuit into a reciprocal one. If the circuit in Fig. 5 is replaced by the parallel connection of the linear coil and the non-linear condenser, and the load connected in series, as shown in Fig. 6, the short circuit current-voltage characteristics of the new circuit will again be identical with those of the graphs in Fig. 4, in which the magnitudes referring to the new circuit are now identified by three dashes. The coil has a straight current-voltage curve:

$$I_L''' = U''' \frac{1}{\omega L}$$

The curve I_2''' (U''') intersects the straight line at the resonance point. Their algebraic sum constitutes the current-voltage curve I''' (U''') of the complete circuit. In the right hand part of the graph a considerable change $\Delta I_1'''$ of the input current I_1''' corresponds to a small change $\Delta I_2'''$ of the output current.

Thus, the circuit shown in Fig. 6 is a current stabiliser instead of a voltage stabiliser. The same behaviour could be expected from a current stabiliser consisting of a parallel connection of a linear condenser and a coil with an iron core operating in the concave part of its voltage-current curve.

RESONANCE-TYPE FREQUENCY MULTIPLIER.

For frequency multiplication, the ferromagnetic circuit shown in Fig. 7 is often used. The voltage across the coil L with a sinusoidal current in its winding will contain several odd harmonics when the iron core is saturated. If the primary loop L, L_1, C_1, is in resonance with the frequency f of the generator, the voltage across L is greatly distorted, whilst the generator operates under optimum conditions. The secondary loop r_2, L_2, C_2 is tuned in resonance with the desired harmonics nf of the frequency, so that the voltage drop of this harmonic is wholly concentrated across the resistance load r_2 and the remaining harmonics are suppressed.

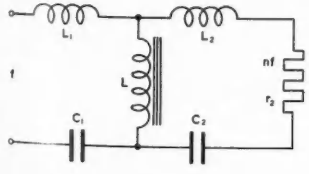


Fig. 7

The resonance-type dielectric frequency multiplier, also operating in the convex part of its voltage-current curve, has a circuit identical with that shown in Fig. 7, with the exception of the non-linear element. The coil with a ferromagnetic core is replaced by a condenser with a rochelle-type dielectric.

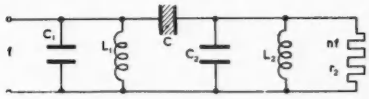


Fig. 8

The circuit of the resonant-type dielectric frequency multiplier operating along the convex part of its voltage-current curve is reciprocal to the circuit in Fig. 7 and is shown in Fig. 8. In this circuit, there are two loops giving current resonance, just as the original circuit contained two voltage resonance loops. In Fig. 7 the desired harmonic is isolated from the voltage across the non-linear element, but in the circuit shown in Fig. 8 the desired harmonic is isolated from the current of the non-linear element. The result is identical in both cases, since the voltage and current curves of the active resistance constituted by the load are entirely similar. For this reason, it is immaterial in the present case whether the circuits considered are supplied by a voltage generator or by a current generator.

COMBINED RESONANCE.

The possibility of a new phenomenon encountered in a circuit containing both a coil with a ferromagnetic core and a condenser with a rochelle-type dielectric, should be pointed out. Series connection of the two elements produces voltage resonance, whereas parallel connection produces current resonance.

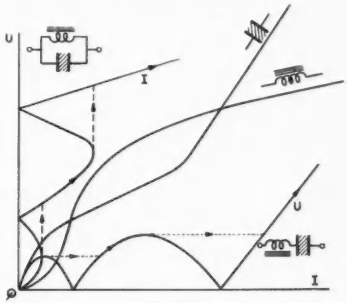


Fig. 9

In Fig. 9, the voltage-current curves of the coil and the condenser are superimposed. In series connection, the voltages, i.e., the ordinates of the curves, are added together; in parallel connection, the currents are combined, i.e., the abscissae of the curves. The sum of the voltages, as well as the sum of the currents, has two minima, corresponding to two resonance points. In the series connection, the circuit has the nature of a capacitance circuit between the origin of co-ordinates and the first resonance point. Between two resonance points, the circuit becomes inductive, and after the second resonance point, it is again capacitive. In parallel connection the reverse sequence applies.

If the second maximum of the sum of voltages is larger than the first (as will usually happen, since the concave part of the voltage-current curve of the coil is less pronounced than that of the condenser), a progressive increase in the voltage across the series circuit

will cause two discontinuities of current, as shown by a dotted line in Fig. 9, and these discontinuities will be accompanied by phase reversal. Similarly, with an increase of current through a parallel circuit, there will be two discontinuities of voltage (broken line in Fig. 9). Curves obtained in a reverse sequence will not coincide with those described. These phenomena can be used in a number of interesting technical applications.

U. S. A.

The Amplistat or Magnetic Amplifier

By W. MILLER. (From *Iron and Steel Engineer*, Vol. 30, No. 5, May, 1953, pp. 65-79, 32 illustrations.)

The magnetic amplifier has been proved to be a reliable and effective tool in regulating systems, but it is unlikely that in the immediate future it will entirely replace the rotating amplifier or the electronic regulator. The magnetic amplifier will probably find its widest application during the next few years working in conjunction with the rotating regulator.

ALTHOUGH saturable core reactors have been used by themselves in power-control devices for many years, their use has been restricted by their slow response and low amplification.

The amplistat, which is a form of self-saturating static, magnetic amplifier, gives a marked improvement in these characteristics of response and amplification, and combines a saturable core reactor and a rectifier in a self-saturating magnetic amplifier circuit. The reactor somewhat resembles a transformer with several windings linking one or more laminated iron cores. However, it differs from the transformer in that the core is designed to be operated in the region of magnetic saturation during part of each saturation. Selenium and germanium metallic rectifiers are most commonly used with the reactors. The output current of this combination, which flows through the output winding of the reactor, has a d.c. component and produces the bulk ot the magnetising force on the core of the reactor. The magnetising force furnished by the d.c. control winding or windings is usually only a small fraction of that furnished by the output winding, but holds the "balance of power" in saturating the core. When the core saturates, the impedance of the output winding and the a.c. voltage induced in it are practically eliminated, permitting a large direct current to flow to control the operation of the system.

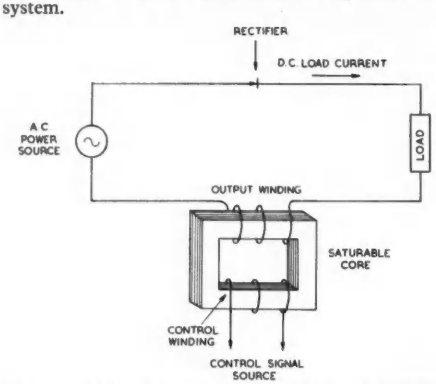


Fig. 1. **Circuit of elementary, self-saturated magnetic amplifier.**

The circuit of an elementary, self-saturated magnetic amplifier is shown in Fig. 1. While this particular circuit has little practical value, because of an objectionably high voltage induced in the control winding, its simplicity is helpful in gaining an understanding of the operation of more practical forms of magnetic amplifier.

Fig. 2 illustrates the part that saturation of the reactor core plays in the operation of a magnetic amplifier. In normal amplistat design, the relation between the rate of increase of the a.c. supply voltage and the rate of

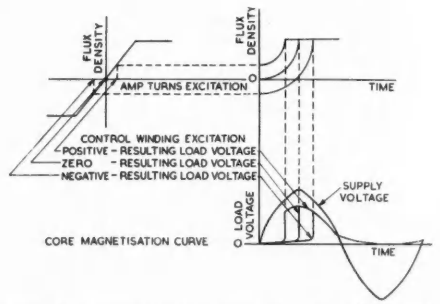


Fig. 2. **Core magnetisation curve, showing effects on flux density and load voltage for various control winding excitations.**

increase of flux density in the core is made such that saturation is reached at approximately the positive peak of the supply voltage, with no applied signal.

With zero signal applied through the control winding, the core saturates during the first half cycle of the impressed a.c. voltage. However, before this point is reached, there is a voltage induced in the output winding of the reactor, which opposes the flow of current. Also, the impedance of this winding is relatively large. When the core saturates, the flux no longer changes and there is no voltage induced in the output winding of the reactor. The impedance of the output winding drops to its resistance value, and a large current flows through the rectifier and the load, super-saturating the core.

When a positive signal is impressed on the control winding, so that the core is partially excited by this winding, the reactor core saturates more quickly than it does with no excitation from the control winding. Thus, a large current flows through the rectifier and the load for a greater portion of the positive half of the a.c. voltage cycle.

When a negative signal is applied to the control winding, opposing the load circuit ampere turns, the core saturates later than with a zero signal to the control winding. Fig. 2 shows that the core actually saturates after the peak value of the a.c. supply voltage is reached. The explanation is that, as in any highly inductive circuit, the magnetising current and the flux produced lag the applied a.c. voltage by almost 90 electrical degrees. Therefore, the magnetising current continues to increase, even as the applied voltage decreases. The magnetising current retains the saturation values after the voltage peak has been reached. Consequently, with a negative signal, the rectifier passes a large current through the load for a smaller portion of the positive half of the a.c. voltage cycle, than when zero or a positive value of d.c. signal voltage is applied to the control winding.

The magnitude of the negative signal impressed on the control winding can be increased to the point where

the core will never saturate, and the amplistat conducts only a very small current through the load.

The variation of d.c. signal input results in control of the firing point between 0 and 180 deg. of the supply cycle. The input power to the d.c. control winding is very small compared with the load current, i.e., considerable amplification can be obtained.

In reality, the core of the magnetisation curve shown in Fig. 2 does not have zero slope above saturation. Also, the forward rectifier resistance is not linear. With these factors considered, the load current wave form of an actual amplistat might be as shown in Fig. 3 for three different firing points. Normally, the control of the firing point over the last 120 deg of the supply cycle can be achieved.

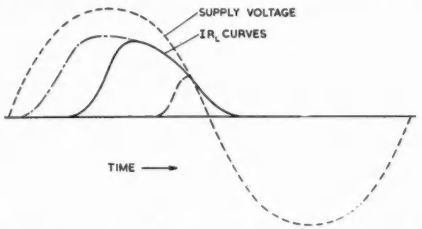


Fig. 3. **Current wave shapes for actual amplistat.**

It should be noted that magnetic amplifiers perform as current amplifiers, while rotating amplifiers act as voltage amplifiers. The magnetic amplifier has the irreversible characteristics of the rectifier, while the rotating amplifier is inherently reversible. For reversing applications, either two generator fields and two magnetic amplifiers must be used, or efficiency must be sacrificed in two magnetic amplifier units to convert them from current amplifiers to a reversing voltage amplifier. In either case, two sets of reactors and rectifiers are required. In the first case, more copper is required on the pole-pieces of the generator, possible resulting in a larger generator. In the second case, larger magnetic amplifier units, with a continuous power loss, are needed. With inductance loads, the efficiency of a reversing magnetic amplifier can be even less than 20 per cent.

The fact that the output or load current of the magnetic amplifier is of a pulsating nature must also be considered. It is the average value of the output current which is important in determining the average flux excitation in a generator, rotating regulator, or another reactor, while it is the r.m.s. value which determines the heating in the excited winding.

Amplification curves for amplistats are somewhat similar to the saturation curves of d.c. generators, except that the output does not reverse when the control signal is reversed. The normal operating range of the magnetic amplifier is selected to be that portion of the characteristic through which the output current varies almost linearly with changes in control signal. The amplification factor, or gain, of the magnetic amplifier is given by the slope of the input-output curve. Since the magnetic amplifier is self-saturating, considerable output is obtained with zero control excitation. Negative excitation, or bias winding, is required to reduce the output to its minimum value.

In a magnetic amplifier, there will be a time delay between the application of the input signal and the response of the output current to this change. The time constant of the magnetic amplifier is generally defined as the time required for the load current to build up to 63 per cent of its final average value, in response to a step function change of control voltage. Since the output current of the magnetic amplifier is affected by the characteristics of the load, this definition of time constant requires a pure resistance load. The time constant of the magnetic amplifier can be controlled by the selection of the control windings, as well as by the use of external resistance. At the expense of over-all amplification, the time constant can be made very short, approaching the theoretical limit of one half cycle of the a.c. impressed voltage. Since the output current appears as pulses, occurring once each cycle, obviously a change in the average output current cannot be observed until the next pulse appears, after the signal is applied to the control winding. As the time constant is very definitely a function of the supply frequency, performance can be improved by increasing the frequency to 400 or even 1000 cycles.

The characteristics of the magnetic amplifier are affected by variations in a.c. voltage and frequency. With more than 100 per cent voltage applied, the minimum possible output current is increased, as well as the maximum output current. With less than 100 per cent voltage, the maximum output current, as well as the range of operation, is decreased. For a given applied voltage, the effect of a decrease in frequency of power supply is similar to an increase in the applied voltage and *vice-versa*. Constant voltage transformers should be used, to minimise the effect of a.c. voltage fluctuations. Frequency variations are rarely large enough to cause concern.

Before the core of the magnetic amplifier reactor saturates, the effect of the load resistance in limiting the small load currents normally flowing, is negligible, compared with the impedance effect of the output winding. After the core saturates, the load resistance becomes the predominant factor in limiting the load current. The optimum load resistance is that which results in the greatest volt-ampere transfer to the load for a given signal change.

Obviously, decreasing the load resistance increases the amplification factor. However, since it is achieved by increasing the maximum load current, such adjustments should be made with caution, lest the rated temperature rise of the equipment be exceeded.

Applications.

Magnetic amplifiers are being used in a wide variety of applications, particularly in the steel industry. Among these applications may be mentioned the following : Power supply for hot strip mills, in which the main drive motors are powered entirely by mercury-arc rectifiers controlled by amplistat regulators ; control of strip tension and regulation of line current in steel mills, using amplistats in conjunction with rotating regulators ; and position regulation systems associated

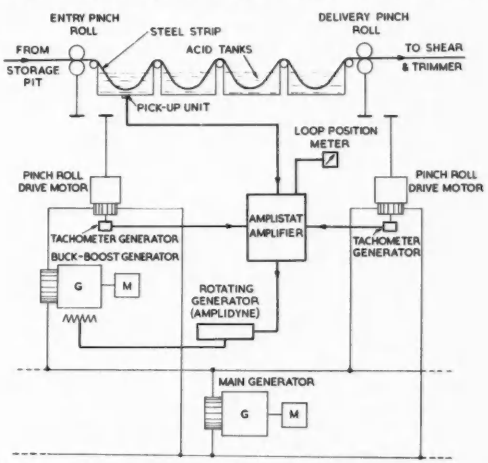


Fig. 4. **Schematic diagram of magnetic loop control system for steel mill pickling lines.**

with preset speed control of tandem cold strip mills and temper mills.

Another application of the amplistat, one which is possibly the most outstanding and widely known in the steel industry, is in magnetic loop control in acid tanks on continuous pickling lines. This magnetic loop control was developed to fill the need for a more rapid, dependable, and easily maintained control of loop position in pickling tanks. This system, which makes possible faster correction of deviations from proper loop position and assures more uniform pickling results, is shown schematically in Fig. 4. An acid-proof magnetic pick-up rests in the bottom of the tank, keeping the strip near the tank bottom for maximum pickling efficiency, but without permitting the strip to scrape the bottom of the tank. Output of the pick-up unit is amplified through an amplistat and rotating regulator to control a buck-boost generator in series with the armature of the pinch roll drive motor. This system controls the speed of the pinch rolls, to regulate the position of the strip loop.

The magnetic pick-up unit consists of a long, closed, two-legged magnetic column, on which are wound three separate windings. One winding on each leg is excited with alternating current. The third winding encloses both legs and is excited by direct current. Most of the d.c. flux is leakage flux and is therefore greatly influenced by the proximity of magnetic material, such as the steel strip. The degree of saturation of the iron core depends on the proximity of the steel strip. The impedance of the a.c. coils depends on the saturation of the core, and hence the current in these coils is proportional to the distance of the steel strip from the pick-up unit. The pick-up unit thus converts flux into an electrical signal, proportional to the loop height, and sends the signal to the amplistat.

The core and coil assembly of the pick-up unit is impregnated with a thermo-setting plastic insulation, and is encased in a lead cylinder. The leads are brought out through a leaden pipe and the entire assembly is covered with alternate layers of plastic and glass tape, which are baked in position for additional protection against acid corrosion. Several of these fixed units have been operating in pickling acid for over three years. They show no signs of corrosion and no changes in sensitivity or operating characteristics.

In the amplistat, the loop position of the pick-up unit is compared electrically with a reference voltage. This voltage is set during initial installation adjustment and usually no further change is necessary. It determines the normal position in which the control will hold the steel strip. The difference signal is amplified by the amplistat, and the output is fed into the rotating regulator.

This magnetic loop control is a position regulator. One of the most effective ways of stabilising such a regulating system is to use a signal proportional to the rate of change of the quantity being regulated. For this system, this quantity is the derivative of position or strip speed. Tachometer generators are used at each end of the tank. The two voltages are compared and the resultant relative speed signal indicates to the amplifier whether the strip is moving up or down. When the relative speed signal is zero, the loop height is not changing. When the pick-up unit signal is normal, the amplistat uses the tachometer signal to hold the entry pinch roll speed in synchronism with the delivery end roll. Thus, accurate synchronisation of pinch roll speed tends to hold the strip loop at normal height, regardless of strip speed. The pick-up unit detects and causes the control to correct any tendency of the loop to drift up or down.

The pickling line operator has no adjustments to make and is not even concerned with loop height control, as the operation is entirely automatic, and a loop position meter is usually mounted at the operator's control desk.

In this system, the smoother control obtained is due to the use of an all-electrical design, with ample power, sensitivity, and speed of response. These characteristics are obtained by using the amplistat and the rotating regulator in combination, and result in close control of loop position, maximum steel under acid, and minimum down time.

SWITZERLAND

The Life of Machines and Components under Variable Loading

By C. Bodmer. (From *Bulletin Oerlikon*, No. 293, February, 1953, pp. 25-30, 6 illustrations).

With constant loading, it is relatively simple to predict the useful life of machines and components. With variable loading, however, the problem becomes more complicated. In the following, a method of estimation of life is suggested, taking into account the main factors involved.

Like all commodities, machines and components lose their value in course of time, wear more or less rapidly according to the intensity of their use, and finally become unfit for service. The time which elapses from the new to the unserviceable state is called the "life."

In order to test the consequences of periodic overloading more accurately, attempts were first made to determine the life of important parts of machines with constant loading. Thus, for instance, the life of organic insulating materials, such as those used for electrical machines and transformers, has been determined in relation to temperature. In these measurements, the loading throughout the test is held constant; as, however, machines and components are in reality mostly subjected periodically to strongly variable loadings, it is important to be able to predict by calculation their life for more complicated loading conditions.

Calculation of Life with Variable Loading.

In order to calculate the life with variable loading, it is usually assumed that changes in loading do not give rise to additional causes capable of influencing the life. This assumption is, however, rarely correct. Thus, for example, the life of a steel spring depends more on the number of load changes than on the duration of a load at rest. Similarly, in electrical machines, every heating change produces expansion and consequent mechanical stresses which age the insulation. These effects can, however, in part be considered separately.

The life is determined by assuming the new machine or component to possess a definite ageing or wear capacity equivalent to the consumption of a reserve. This reserve becomes consumed by friction, by combustion, by material changes, or by chemical, thermal, or electrolytic action and solution.

Consider the following simple example of consumption: A vessel, filled with water and provided with a variable outlet, corresponds, on being emptied, to the transition from the new to the aged state. Let the total liquid content be the reserve $Z = 1$. The quantity of water flowing through per second corresponds to the rate of wear or ageing $V = dZ/dt$, and this depends

both on the size of the outlet and on the water level. The total time of the discharge is the life T.

For the purpose of a simple derivation of the method used here, the assumption is made that wear takes place linearly with time. The rate of ageing V is then constant and equal to $1/T$. Now consider a load cycle of duration T_0, made up of individual intervals t_1, t_2, t_3, etc. During the interval t_1, the load is supposed to be such that it would correspond to a life T_1, provided it were constant. Thus, a partial wear $z_1 = V_1 t_1 = t_1/T_1$ sets in. The total wear Z_0 during the load cycle is thus

$$Z_0 = z_1 + z_2 + \ldots = t_1/T_1 + t_2/T_2 + \ldots$$

This wear corresponds to an average rate of wear V_m, so that $Z_0 = V_m T_0$. Moreover, with an average rate of wear V_m, the resulting life is T_r, from which $V_m = 1/T_r$. Hence T_r is the inverse of V_m.

Thus, $T_r = 1/V_m$ and

$$V_m = \frac{1}{T_0}(t_1/T_1 + t_2/T_2 + t_3/T_3 + \ldots)$$

As a practical example, take the case of a transformer, in which it is assumed that, with a temperature of 105°C in the copper winding, the life of the transformer is 40 years, and that, as indicated by Montsinger*, the life of certain insulating materials is halved with a rise in temperature of 8°C.

Then, with the following copper temperatures, the life at constant temperature would be :

at 145°C =	1·25 years	at 105°C =	40 years
137°C =	2·5 ,,	97°C =	80 ,,
129°C =	5 ,,	89°C =	160 ,,
121°C =	10 ,,	81°C =	320 ,,
113°C =	20 ,,	73°C =	640 ,,

Now, assume that the loading of the transformer to be such that its daily temperature amounts to 89°C for 10 hours, 113°C for 2 hours, 121°C for 1 hour, and 145°C for 20 minutes (0·33 hour), corresponding to an overload of about 30 per cent. During the remaining 10·67 hours of the day, the temperature is assumed to be 73°C, corresponding to about 75 per cent of the rated load. During the load cycle of 24 hours, the individual portions of the ageing are thus :—

$$z_1 = \frac{10}{160};\quad z_2 = \frac{2}{20};\quad z_3 = \frac{1}{10};$$

$$z_4 = \frac{0{\cdot}33}{1{\cdot}25};\quad z_5 = \frac{10{\cdot}67}{640}$$

so that

$$V_m = \frac{1}{24}(0{\cdot}063 + 0{\cdot}100 + 0{\cdot}100 + 0{\cdot}264 + 0{\cdot}017) = 0{\cdot}0227$$

Thus, the life is $T_r = 1/0{\cdot}0227 = 44$ years.

Closer examination of these figures shows that the 20 minute overload z_4 makes an appreciable difference, as, without this overload,

$$T_r = 1\Big/\left(0{\cdot}0227 - \frac{0{\cdot}264}{24}\right) = 1/0{\cdot}0117 = 85 \text{ years}$$

On the other hand, the ageing with reduced loading z_5 has little effect, as, in this case, by neglecting this portion,

$$T_r = 1/0{\cdot}0220 = 45 \text{ years.}$$

Range of Validity of the Method Employed.

The assumption made for the derivation of the method that the reserve available for the wear is expended linearly with time will not as a rule be true. It is, however, found to be satisfactory when the curves of ageing are similar to each other. This similarity of the curves of ageing implies that they are mutually convertible by changing the time unit. Then, (see Fig. 1):

$$V = dZ/dt = \tan\alpha = p/T$$

where $p = f(Z)$ is a function of ageing Z. During the time T_0 of the load cycle, it is assumed that p remains practically constant. Then, for the wear Z_0,

$$Z_0 = \int V\,dt = V_1 t_1 + V_2 t_2 + V_3 t_3 + \ldots$$
$$= pt_1/T_1 + pt_2/T_2 + pt_3/T_3 + \ldots$$

The average rate of wear V_m is defined by $Z_0 = V_m T_0$, to which the resulting life T_r corresponds. Thus, $V_m = p/T_r$, and as

$$Z_0 = V_m T_0 = p(t_1/T_1 + t_2/T_2 + t_3/T_3 + \ldots)$$

it follows that

$$T_r = \frac{T_0}{t_1/T_1 + t_2/T_2 + t_3/T_3 + \ldots}$$

As p is assumed constant for the duration of the load cycle, it drops out of the calculation and the same relationship as for a linear curve of ageing is obtained. Thus, the method also holds good when the curves of ageing are curvilinear and similar to each other, provided that the duration of the load cycle remains small in comparison with the life. This condition is always fulfilled in practice, for a week, or even a month, as the duration of the load cycle is always sufficiently small compared with a life of several years. The assumption that the curves of ageing are similar should hold for most phenomena of ageing, particularly within that range of conditions in which the causes of ageing remain the same, and hence where no additional cause gains the upper hand.

*Loading Transformers by Temperature. *Trans. A.I.E.E.* 49 (1930), p. 776.

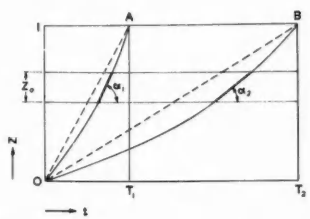


Fig. 1. **Ageing curves, assuming course to be similar.**
Z_0 = ageing during load cycle.
T_1, T_2 = life with definite loadings.

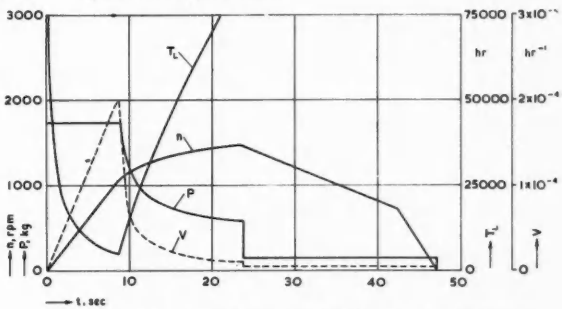


Fig. 2. **Graphical determination of the life of a roller bearing.**
n = motor speed, rpm.
P = loading of roller bearing, kg
T_L = life with constant loading
V = rate of wear or ageing.

Graphical Determination of Life

As an example of graphical methods of life determination, consider the case of a roller bearing, where it is assumed that no additional causes, capable of shortening its life, are produced by a change in service conditions.

The roller bearing, of which the actual value of its life can be taken from catalogues on roller bearings, is assumed to be built into the motor of a tramcar operating daily for 16 hours, with running times of 47 seconds and stopping times of 10 seconds. In Fig. 2, n is the graph of the motor speed and P the graph of the loading of the roller bearing, representing a heavy service. From n and P the life T_L in hours is found from the maker's catalogue for each service condition. From T_L, the graph of the rate of ageing V is obtained as the reciprocal value: $V = 1/T_L$. The area beneath the line V represents the integral $Z_0 = \int V\,dt$ and thus the total ageing per run. The magnitude of this area is $13{\cdot}6 \times 10^{-4}$ seconds per hour. To obtain the average rate of ageing V_m from this value, the ageing Z_0 must first be based on the time of the run, including the stops. Hence,

$$V_m = \frac{1}{57} \times 13{\cdot}6 \times 10^{-4} = 0{\cdot}24 \times 10^{-4}$$

Owing to operation for only 16 hours per day, however,

$$V_m = \frac{16}{24} \times 0{\cdot}24 \times 10^{-4} = 0{\cdot}16 \times 10^{-4}\ \text{hr}^{-1}$$

Hence, the resulting life T_r is

$$T_r = 1/V_m = 10^4/0{\cdot}16 = 62{,}500\ \text{hr} = 7{\cdot}1\ \text{years.}$$

As the assumed loading P is not really so large during the whole of the day, the life is actually longer. This circumstance could be covered by considering several such load diagrams in place of one only.

As an additional example, take the case of the life of the windings of the tramcar motor, into which the roller bearing previously considered, was fitted. The heating of the winding in the course of a day depends on the traffic density and is shown in Fig. 3. In order to obtain the absolute temperature, the temperature of the ambient air, which changes in the course of the day and year, must be added. The windings are assumed to be insulated with materials of "Class B" insulation for which, as shown in Fig. 4, the life (Curve 1) and the rate of ageing (Curve 3) are plotted in relation to the temperature. These curves have been derived from the curve of the life for "Class A" insulation (Curve 2).

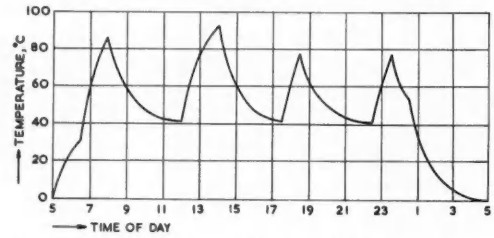


Fig. 3. **Rise in temperature of the winding of a tramcar motor during 24 hours.**

Suppose that in summer the air temperature rises from 15°C in the early morning to 31°C in the afternoon, giving an average of 23°C. Under these conditions, a graphical determination similar to that shown above for a roller bearing gives a life of 32 years. Making the same graphical determination for a winter's day, with temperature limits of —4°C and +4°C, the expected life rises to 94 years. For still lower temperatures, the life would increase still more, but the effect on the final result would be imperceptible. Now, in the course of a year, the temperature varies approximately sinusoidally, and if in a similar manner the calculation is extended over the whole year, an average value corresponding to a life of about 51 years is obtained. For a day mileage of, say, 125 miles, the motor will, therefore, give promise of a life mileage of about 2·3 million miles.

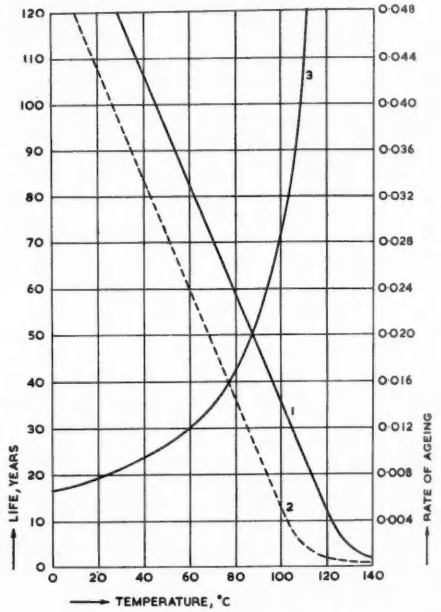


Fig. 4. **Assumed life for "Class B" insulation materials.**
(1) Life of "Class B" insulation.
(2) Life of "Class A" insulation (for comparison).
(3) Rate of ageing or wear of "Class B" insulation.

From this example it can be seen that the calculation of the life can give an indication of how a machine will behave under changed climatic conditions. If the same calculation is made for the changed temperature conditions of other countries, the approximate effect on the life can be determined, and admissible loadings, to obtain the same life, established.

Conclusions.

Calculations of this kind are instructive for the estimation of the absolute value of the life of machines and components, but still more important, however, is the knowledge gained as to what loadings specially prejudice the life and what highest admissible temperatures are still economical. In particular, it enables estimation of the degree in which high, but infrequent, overloads of short duration lessen the life in individual cases, as compared with moderate overloads of long duration.

The determination of the probable life of machines and components is valuable for the appropriate dimensioning of certain machine elements. Although it is better for the life chosen to be too long rather than too short, an excessively long life would entail extra costs, resulting in useless expenditure.

Experience so far gained of the life of equipment at constant temperature is still incomplete. This is especially true in the case of windings insulated with modern materials. Only additional investigations and experience will provide sufficient data for ensuring more accurate results in the case of variable loads.

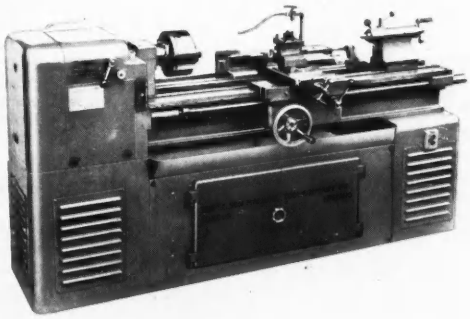
New Materials, Processes and Equipment

UNIVERSAL OIL GROOVING MACHINE

A new universal oil-grooving machine, designed to cut any type of oil groove quickly and economically, has been produced by Trojan Limited, of Croydon.

The new machine, shown in the accompanying illustration, will produce all the standard oil grooves normally called for on outside and inside diameters, external and internal taper, and on faces of components. Multiple oil grooves are cut continuously by the generating process and each groove is symmetrical on each side of the centre line.

The machine eliminates the disadvantage of cutting each groove separately and indexing the component. Grooves are cut progressively in the same operation, without stopping the machine, generation being accomplished by variable gearing, enabling the tool to oscillate a desired number of times to one revolution of the workpiece.



From one to twenty-four grooves per piece can be cut, and the machine can also be used, if required, for cutting external and internal keyways and splines.

The Selson Machine Tool Company Limited, of North Acton, have been appointed sole world-wide agents for this machine.

ELECTRO-PNEUMATIC FUEL TANK PRESSURISATION

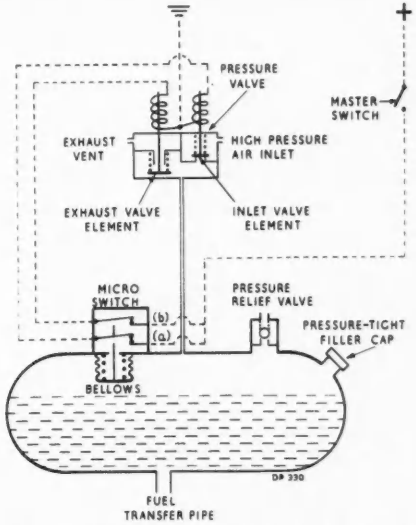
A simple, lightweight fuel pressure-transfer system has been produced by the Dunlop aviation division, by means of which the tanks need be pressurised only while fuel transfer is taking place.

The system permits the tank to be coupled to a 3000 psi air supply, and allows this pressure to be reduced to any desired operating pressure through a single pneumatic valve and a pressure-operated switch.

The pressure valve, coupled to the fuel tank, is provided with solenoid-operated inlet and exhaust valves, so arranged that when the current is off the inlet valve is closed and the exhaust is open.

Attached to the tank is a pressure-operated switch containing two sets of quick make-and-break contacts; a sealed, spring-loaded bellows assembly sensitive to tank pressure; and the base plate of the bellows carrying a plunger which protrudes through the tank wall to oppose the arm of the contacts (a), as shown in the illustration.

When fuel transfer is required, the pilot operates the master switch, thereby energising the pressure valve



solenoids. The exhaust valve closes and the inlet valve opens, allowing air pressure to pass to the tank. Increasing pressure in the tank collapses the bellows until, at the required tank pressure, the plunger contacts the arm of the contacts (a) to break the circuit to the inlet valve solenoid, and the valve closes under the action of its return spring. During the transfer of fuel, the bellows will expand slightly as the pressure tends to drop. This expansion will withdraw the operating plunger, and contacts (a) will close to re-energise the inlet valve solenoid, thus opening the valve to admit more air.

If, due to temperature rise or any other cause, there is a rise of pressure in the tank above that required for fuel transfer, a further compression of the bellows will take place. This will result in a greater movement in the arm of the switch contacts (a). The small plunger attached to this arm will contact the arm of the contacts (b) to break the contact and de-energise the exhaust valve solenoid, thus opening the exhaust valve, to permit the excess pressure to escape.

GROUND POWER SERVICING AND STARTING MOBILE UNIT FOR AIRCRAFT.

As the result of a requirement by British Overseas Airways Corporation, calling for a dual-voltage combination of electrical ground power in excess of that usually available, to meet forthcoming Comet II and III and Bristol Britannia operations, a new universal servicing and starting mobile unit has been developed by Crompton Parkinson Limited and Auto Diesels Limited, of London, in collaboration with B.O.A.C.

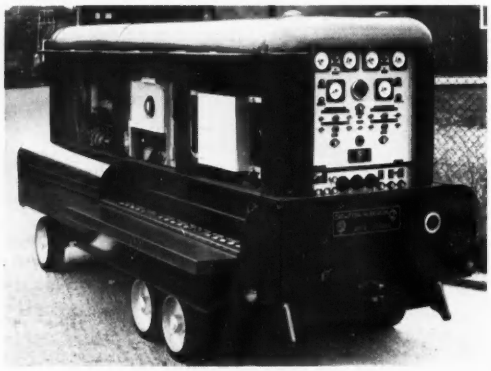
The new unit consists of a Leyland diesel engine driving two generators, giving outputs of 450 A continuously at 112 V for starting and 750 A continuously at 28 V for servicing. In addition, the unit will supply peak starting currents of 850 A at 112 V and 2000 A at 28 V. Simultaneous outputs for 28 V servicing and 112 V starting are permissible up to 100 kW.

The compound-wound generators are built to a special Crompton Parkinson design to meet the exacting

requirements of this application and, for the first time automatic voltage regulators are not employed. Close regulation is achieved, with complete absence of oscillatory voltage surges, and tests have shown that inherent voltage regulation is held even with shock loads of 500 per cent above full load current.

The unit includes two batteries giving 24 V and 96 V respectively. When the generating set is running, the 24 V battery is connected in parallel with the 28 V generator and the 96 V battery in parallel with the 112 V generator. With this arrangement, the batteries are charged when the set is running.

When the set is giving a 28 V supply for servicing, if the generator is switched off, or the engine is shut down, for example, during aircraft refuelling, the servicing supply is maintained from the 24 V battery, which can also be used in the event of a starting supply being required when the set is shut down. The 96 V battery is provided only for starting when the set is shut down.



Engine instruments, including rpm indicator and hours counter, electrically operated remote control oil pressure gauge, etc. are all conveniently grouped on the main control panel. A push-button controlled contactor system enables individual selection of any or all supplies, i.e., 24 V and/or 96 V batteries, alternatively 28 V and/or 112 V generators. The contactors are high speed, heavy duty, solenoid-operated types, and contactor closure is indicated by panel pilot lamps and also by vehicle roof lamps for aircrew observation.

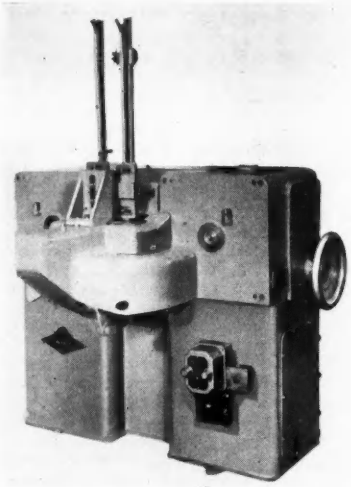
Positive protection is provided against overload, generator over-voltage and reverse current (resulting from feedback from aircraft batteries or generators) by means of a new technique employing high-grade, sensitive relay instruments and associated high-speed main contactor tripping relays. Reverse current tripping operates at minus 2 per cent of full load current. Generator contactors can be closed only when the generated voltage is in excess of the associated battery volts and cannot be closed if the generator polarity has been reversed while the set is shut down. Equipment is incorporated to eliminate radio interference.

IRREGULAR TRIMMING MACHINE

A new model fully-automatic irregular trimming machine, for use in the manufacture of non-circular seamless tinplate containers, has been introduced by F. J. Edwards Ltd., of Euston Road, London.

The illustration shows the new model, known as the "Besco" Model 65 Irregular Trimming Machine, which is designed to trim irregular pressings from 3 × 2 in. to 6 × 4 in. in 30 s.w.g. tinplate or equivalent. Smaller and narrower boxes can be trimmed with special tools.

At a rate of 45 to 60 per minute, the containers are fed completely automatically to the trimming head down an easily-adjustable chute and/or direct from the

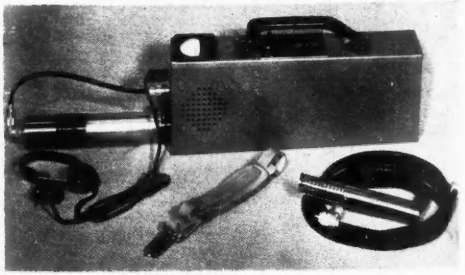


press itself, and subsequently removed, the shredded trimmings falling away down another chute separately to the trimmed pressings, which are also automatically ejected. No operational skill is required.

The trimming plate is a solid ring of heat-treated alloy steel. A special handwheel controls the setting, and when in use, automatically cuts out the motor switch. For each size of container, a set of trimming equipment is required. The maximum and minimum depth of pressing are 1 in. and ¼ in. respectively.

ULTRA-SENSITIVE PROSPECTORS' GEIGER COUNTER

The Radiac Co., Inc., New York, have developed an ultra-sensitive Geiger Counter, known as the Model 105-D Prospectoscope, for radio-active mineral prospecting. The new counter can be used for prospecting from low-flying aircraft, from a moving vehicle or on foot, and also for probing drill holes to depths of 50 ft.



The prospectoscope is reputed to be equipped with the largest gamma-sensitive Geiger tube ever placed in a survey instrument. The overall length of the tube is 26 in. and the diameter is 2 in., giving the prospectoscope a sensitivity 30 times greater than that of any other standard Geiger tube. It can be taken out of the instrument and fitted with ease to the 50 foot coaxial cable provided.

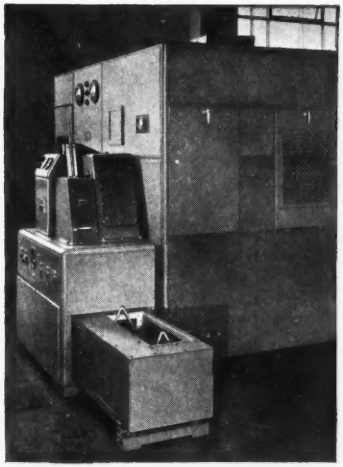
The prospectoscope also features a standard size beta-gamma Geiger probe, which is interchangeable with the tube. An accurate meter, with five ranges, gives the prospector a wide selection of instrument sensitivities. A built-in speaker gives an aural indication of radioactivity. For aerial surveying, where aircraft engine noise may be excessive, earphones are provided. The weight of the complete instrument illustrated is 14lb.

H.F. BAR STOCK HARDENING MACHINE

The latest addition to the range of high frequency induction heating machines manufactured by The General Electric Co. Ltd., London, is a bar stock hardening machine for the surface hardening of steel bars. It is designed for use with hardenable steels, rather than with carburised bars, and can be adjusted to deal with sizes from $\frac{1}{2}$ in. diameter to $1\frac{1}{4}$ in. diameter.

Operation is continuous, the bars being placed one at a time against the top of an inclined V-slide and allowed to pass down the slide and through the heating coil. The speed with which the bars pass through the heating coil is goverened by two driven V-rollers, one above and one below the heating coil. Both rollers are geared together and driven by the same prime mover.

The heating coil puts all the available power into a very short axial length of skin, causing it to heat rapidly to hardening temperature. The thickness of the hardened case depends upon the speed with which the bars are caused to travel through the heating coil, but may conveniently be between 0·020 in. and 0·10 in. Great care has been taken to ensure a symmetrical case and uniform speed of drive.



Immediately below the heating coil is the angular quench box, through which the heated zone passes when it leaves the heating coil. As each treated bar is finished, it slides down a chute and is collected in a basket at the bottom.

The machine illustrated is rated at 25 kW output, and, when treating 1 in. diameter bars at 30 in. per minute, gives a hardened case 0·025 in. thick.

ELECTRONIC TEMPERATURE AND HUMIDITY CONTROLS.

In addition to their well-known range of TEM-CON thermostatic elements, Messrs. P.A.M. Ltd., of Guildford, are now featuring two new elements, for radiation and humidity respectively.

The radiation element, which has been designed specifically for the control of hot, moving surfaces, comprises a flat strip of high-expansion metallic foil suspended by its ends in a casing, which exposes one side of the strip to radiation from the hot surface, and yet protects it from draughts and other radiation. The exposed surface of the foil is specially prepared to absorb radiations from the hot surface readily and, under suitable conditions, control within $\pm$ 2½°C can be obtained.

The humidity element is of the hygroscopic type, the operative member consisting of a short piece of specially selected material, so suspended as to be unaffected by temperature changes. Mechanical protection, with adequate ventilation, is provided by a slotted metal sheath. The control will operate consistently at 95 per cent R.H. at 110°F and also under dry conditions, such as 10 per cent R.H., to within ± 0·5 per cent R.H.

Both controls are intended for use with the TEM-CON electronic relay, by means of which switching of currents up to 8 A at 200-250 V a.c. can be obtained.

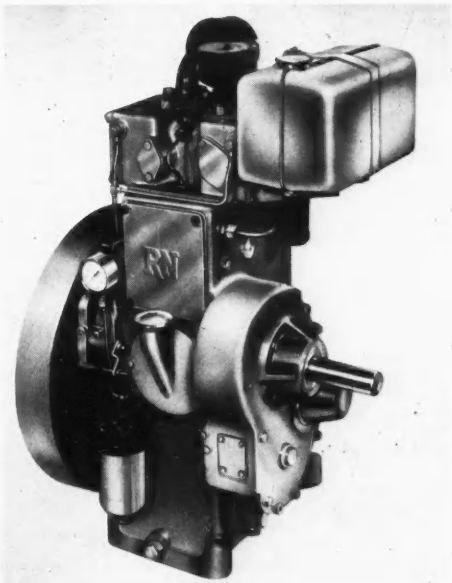
NEW SMALL DIESEL ENGINE

A new diesel engine, the "HUSKY," designed to meet all requirements for a small prime-mover, has been introduced by Russell Newbery & Co. Ltd., of Dagenham. It is a vertical, single-cylinder engine, with a bore of $3\frac{3}{4}$ in. and a stroke of $4\frac{1}{2}$ in., providing 5 to 8 hp on a 12-hour rating basis, over its speed range of 1000 to 1500 rpm.

Its design makes it particularly suitable for the requirements of manufacturers of contractors' plant, agricultural machinery and diesel electric sets.

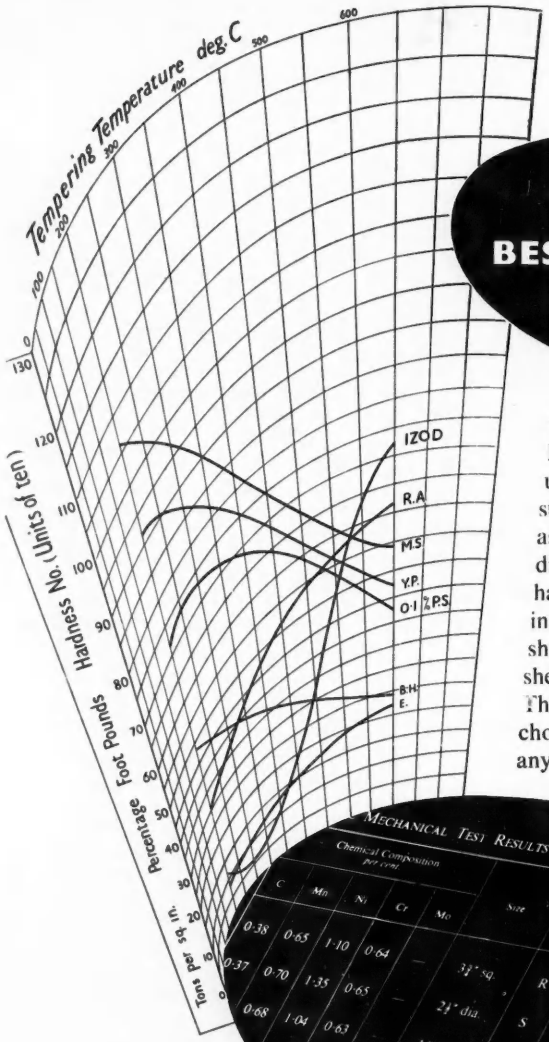
The engine has been under development for over four years, and a number of prototypes has been built, two of which have seen considerable service under severe conditions in India.

The cylinder head follows the usual Russell Newbery practice, which enables the engine to run on low-grade fuels. The valves can be serviced without removing the head or piping. The cast-iron crankcase carries one integral and one detachable main bearing housing, to facilitate crankshaft removal, and also incorporates a renewable wet-type cylinder liner. The piston is of low-expansion aluminium alloy; the connecting rod is an



"H" section alloy steel stamping, with the big end bearing split at an angle to simplify its removal through the cylinder bore.

A simple governor of the firm's own design, controls the engine speed, and the C.A.V. fuel equipment incorporates a self-cleaning, pintle-type nozzle. Cooling is by thermo-syphon, in conjunction with cooling tanks or radiator, and the engine can be supplied with either single or twin flywheels. A half-speed power take-off shaft can be provided.



THE BEST STEEL FOR THE JOB

Our publication, "The Mechanical Properties of Nickel Alloy Steels" contains useful design data for a wide range of steels. Curves and tables of properties (such as these shown here) are given for 30 different direct-hardening and case-hardening nickel alloy steels, together with information on specifications and relationship between tensile strength, hardness, shear and torsional strengths.

This publication will assist the designer to choose the most suitable nickel alloy steel for any given purpose. *Write for a free copy.*

MECHANICAL TEST RESULTS

Chemical Composition per cent					Size	Tensile Range Symbol	Heat-Treatment		Mech		
C	Mn	Ni	Cr	Mo			Harden °C	Temper °C	Y.P. t.s.i.	M.S. t.s.i.	Elong. per cent
0·38	0·65	1·10	0·64	—	3½" sq.	R	O.Q.830	600	36·8	50·9	26
0·37	0·70	1·35	0·65	—	2½" dia.	S	"	"	47·4	55·6	22
0·68	1·04	0·63	—	—	1½" dia.	T	"	"	50·8	59·2	21·5
1·23	0·62	—	—	—	1½" dia.	U	"	580	61·1	66·5	20·5

Tempering curves and table showing the properties obtainable with different ruling sections for a low nickel-chromium steel to Specification En 111.

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CLASSIFIED ABSTRACTS

Numerous important abstracts which, for lack of space, cannot be published in our main editorial columns, are regularly included in condensed form in this section. Subscribers may obtain photostat copies of all original articles at cost.

BEARINGS

An Analysis of the Pivoted Pad Journal Bearing

By W. L. KENNICOTT. (From *Mechanical Engineering, U.S.A.*, Vol. 75, No. 5, May, 1953, pp. 380-386, 17 illustrations.)

THE hydrodynamic wedge is automatically made possible in the plain journal bearing by the physical necessity of constructing the journal somewhat smaller in diameter than the bearing.

Since no such fortunate situation exists in the case of flat rubbing surfaces, special designs are necessary before the wedge principle can be adapted to plane sliders or to thrust bearings.

When Kingsbury and Michell succeeded in applying this principle to thrust bearings by the introduction of pivoted pads, it was only natural that the highly satisfactory results which they obtained should suggest that similar advantages could be obtained by applying such pads to journal bearings themselves.

However, since plain journal bearings already incorporate the features of the hydrodynamic wedge, it is evident that the application of pivoted pads will not produce in this case the degree of improvement possible from a similar application in thrust bearings.

In view of the usual practice of constructing all pads alike and spacing them uniformly around the circumference, the present analysis is confined to pivoted-pad journal bearings of this design. Performance characteristics are shown, types of loadings and their effect on load capacity and journal displacement are discussed, and comparisons are made between pivoted-pad and plain journal bearings.

The superiority of pivoted-pad journal bearings over plain journal bearings is a subject that has been strongly argued. The present treatment, however, shows that the plain journal bearing compares favourably with the pivoted-pad bearing and by many criteria is somewhat superior. This, however, does not mean that the pivoted-pad bearing has no important advantages. High on the list is its ability to accommodate shaft angularity, although a journal bearing arranged to pivot as a unit would also have a similar advantage. Another advantage of the pivoted-pad bearing is its freedom from oil-whip instability.

An ideal application for such pivoted pads is on large-diameter, lightly loaded, vertical-axis guide-bearings. Here, the pads may be made comparatively small and the power loss reduced to a fraction of that obtained with a plain journal bearing.

However, no striking advantages over plain journal bearings can be shown on the basis of the properties determined in the analysis. Any real advantage over plain journal bearings would appear to be associated more with practical rather than with theoretical considerations.

FOUNDRY PRACTICE

Chain Shot-Blasting Machine for Cleaning Castings

By J. HOROSZKO. (From *Przeglad Odlewnictwa, Poland*, 1953, No. 1, pp. 19-22, 3 illustrations).

OPERATING data and a description are given of a chain shot-blasting machine for cleaning castings weighing up to 90 lb. The machine was designed by the Polish Central Design Office for foundry machines and equipment, and it is emphasised that since this machine operates without compressed air, it can be installed in old foundries, where the cleaning of castings presents a bottle-neck in production.

The machine consists of a box in which an upward sloping caterpillar conveyer runs at the speed of about 14 fpm. Castings placed on this conveyer rotate, due to the upward movement, and thus rub against each other and the chains of the caterpillar conveyer. Simultaneously, they are subjected to a stream of cast iron shot propelled by a rotor operating at 2,320 rpm. In this way the machine combines the principles of shot-blasting and tumbling. The used shot, together with sand, nails, etc., falls through the openings in the conveyor, is sieved, separated from sand by suction, and returned to the rotor. The direction of the stream of shot can be regulated. The parts of the rotor most subject to wear are made from white iron, cast in chill moulds, and are easily replaceable, the life of the throwing blades of the rotor being estimated to be from 8 to 16 hours.

The machine weighs about 6 tons, is 172 in. in height, and occupies a floor space of approximately 90 × 108 in. The weight of a single load is about 900 lb and loading and unloading time is from 4 to 10 min. Throughput is from 0·8 to 4 tons per hour, and the time of a cleaning cycle from 2 to 20 minutes, depending on the material from which the castings were made.

FLOW OF FLUIDS

The Design of Rotational Viscometers

By R. SCHWABEN and H. UMSTAETTER. (From *Konstruktion, Germany*, Vol. 5, No. 3, March, 1953, pp. 79-95, 15 illustrations).

IN the first part of this article, equations for viscous flow of a liquid under the action of a rotating body are developed, to determine the viscous shear stresses and torque. The conditions occurring in a conical type viscometer are then investigated for the case of constant gap width, and the angular velocity of flow is expressed by means of Bessel functions. The general expression for the viscous torque is used to obtain solutions for a cone apex angle of 70·5 deg in a gap of finite width, in an unbounded fluid and for the limiting case of a cylinder. Fairly simple relations are also obtained for conical viscometers having a gap with a double conical taper. Formulae for the evaluation of spherical and cylindrical type viscometers are also derived. Precautions are indicated to avoid wall effects due to the bottom surface. A formula for the conical-frustum type viscometer is given, based on a more exact theory than the original Umstätter formula previously published. Instrument constants are set out for the various cases.

The second part describes three types of viscometers of recent construction, *viz.*:

Umstätter "Consistometer": This viscometer has a narrow, slightly tapering gap between the rotatable inner cone and the outer body. The inner cone is attached to the bottom end of a vertical shaft, which is rotated by means of a weight acting through a cord-and-pulley arrangement. The lower part of the body is kept in a constant-temperature bath, also contained in

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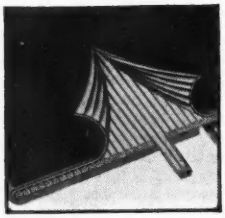

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Goodyear Endless Cord Belts successfully tackle a complicated drive with six changes of direction. This is a sanding machine in the woodwork factory of Craigs Ltd., timber merchants at Widnes. Tough, dependable Goodyear belts are used exclusively throughout the plant.
(NOTE. The guards have been temporarily removed from this drive to facilitate photography.)

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the apparatus, and held at the required temperature by a heater ring. The angle of rotation is read on a circular scale on the upper cylindrical extension of the body. Small angles are measured by means of a mirror and autocollimator lens system. All parts are easily cleaned.

"*M.P.A. Dahlem*" *remote-indicating viscometer*: The apparatus has an inner cone driven by a d.c. control motor with permanent-magnet excitation. This motor has a driving torque of 3·6 cm gr/volt and reaches a maximum speed of 1500 rpm. The d.c. voltage, variable from 0·1 to 24 V, is derived from a mains-connected rectifier and stabiliser unit which is coupled to a Wheatstone bridge, with the motor in one branch and adjustable resistances in the other branches. The bridge output is fed to a galvanometer, which may be calibrated directly in centipoises or poises. Decade resistors give a number of measuring ranges and the bridge can be switched over to various motor-controlled viscometer elements, used at different positions to supervise manufacturing processes, etc. For highly viscous substances, spheres can advantageously be employed, in place of cones. When required to operate at fairly high temperatures (maximum 80° C), the control motor is protected by a water jacket. For automatic control applications, the motor is coupled to a second control motor of the same type, operating as a tachometer generator. For high or low temperature operation, a thin-wire suspension is used and the cone is replaced by a circular disc, to ensure maximum stability.

"*Thixometer*." This is a precision apparatus for laboratory work. It comprises a motor-driven outer cylinder and an inner cylinder suspended from a thin torsion wire. The entire unit is enclosed in a constant-temperature water jacket. The outer cylinder is driven through differential gears by two electronically controlled d.c. motors, of the type described above. The apparatus is particularly suitable for the study of low-viscosity fluids and can be used to determine the effects of low creep rate or high velocity gradients on viscosity over a period of time.

PLASTICS AND PLASTIC PRODUCTS

Effect of Preloading and Mechanical Fatigue on Mechanical Properties of Glass-Cloth Plastic Laminates

By A. D. FREAS. (From *Transactions of the A.S.M.E., U.S.A.*, Vol. 75, No. 4, May, 1953, pp. 621-633, 15 illustrations).

IN aircraft structures, increasing use is being made of glass-cloth plastic laminates. Tests on materials of this type were carried out by the Forest Products Laboratory (F.P.L.), U.S. Department of Agriculture, in co-operation with the Sub-Committee on Aircraft Design Criteria, Aircraft Committee, Munitions Board. Tests were made on specimens $\frac{1}{8}$ in. thick (12 to 13-ply) and $\frac{1}{4}$ in. thick (9 to 84-ply), with specific gravities of 1·69 to 1·87. Resin contents varied from 29·9 to 43 per cent, and Barcol hardnesses between 65 and 70.

Tensile and compression tests (F. WERREN, F.P.L.): The materials investigated were a satin-weave fabric (181-114) with similar properties in directions parallel and perpendicular to the warp direction, and a unidirectional fabric (112-114). Both were parallel-laminated with an alkyd-styrene resin. Additional wet and dry tests were made with a cross-weave laminated fabric (143-114), a coarse-weave laminate (181-114), and a parallel-laminated fine-weave fabric (112-114). Dumbell-shaped specimens were used. The deformations were measured by optical means (Marten's mirrors) or with "metalectric" strain gauges.

The load/deformation curves of some laminates can be approximated by two straight lines, corresponding to a primary and a secondary elasticity modulus E_1 and E_2 (the latter has the lower value of the two, corresponding to the somewhat reduced slope of the upper portion of the curve). Owing to the set occurring during the initial loading, the unloading curve is somewhat steeper and the second loading curve follows a path somewhat to the left of the unloading curve. For laminates which do not exhibit this effect, the shape of the curves does not appear to be affected by preloading. The final elasticity modulus E_f varies, for the dual-curve laminates, according to the preload but approaches the secondary modulus for high preloads, while remaining 3 to 14 per cent above it. Typical values for laminate 181-144 are as follows:—Tension: $E_1 = 3{,}080{,}000$, $E_2 = 2{,}640{,}000$, and $E_f = 3{,}000{,}000$ psi. Compression: $E_c = 3{,}240{,}000$ psi. Laminate 143-114 reaches an E-value above 5,000,000 psi. Preloading has fairly similar effects on laminates in either dry or wet condition, and does not appear to affect the maximum static tensile strength.

Fatigue Tests (K. H. BOLLER, F.P.L.): Three materials were investigated, viz.: fabric 181-114 parallel-laminated with alkyd-styrene resin, fabric 181-114 parallel-laminated with diallyl phthalate-alkyd resin, and fabric 143-114 cross-laminated with alkyd-styrene resin. Unnotched and notched specimens were tested in a direct-stress fatigue machine operating at 900 cycles/min. Loads at zero deg. and 45 deg. to warp were applied. The effects of exposure to temperature (75° F) and relative humidity (50 to 100 per cent), before or during the tests, were also investigated. In some tests, the specimens were loaded through a pin inserted in a hole at the minimum section.

The static strength values were markedly lower at 45 deg. than at 0 deg. to warp. It was found that specimens tested parallel to warp gave similar fatigue strength values, ranging from 0·25 to 0·33 of the static tensile strength (*STS*), the lower value applying in most cases to notched specimens. No constant fatigue-strength limit (endurance limit) was reached, even at 10 million cycles. Specimens tested at 45 deg. to warp showed considerably lower values, both as regards *STS* and *FS* (fatigue strength). The endurance limit (constant *FS* limit) was reached at about 40,000 cycles. The *FS* of specimens loaded at 45 deg. to warp is reduced by moisture to a greater extent than in the case of loads parallel to warp.

PUMPS

Effect of Changes in Speed and Size on Homologous Centrifugal Pumps

By A. E. ROACH. (From *Machine Design, U.S.A.*, Vol. 25, No. 6, June, 1953, pp. 183-185, 2 illustrations).

TWO problems frequently arising in the application of centrifugal pumps are concerned with the relative best efficiency characteristics of a pump operating at different speeds, and of similar types of pumps of different sizes.

Although, at present, there is no satisfactory general theory for centrifugal pumps, it is possible to derive simple and reliable answers to these problems from the affinity laws for homologous pumps, i.e., pumps which are exact geometrical images of each other.

Affinity Laws: The efficiency of a centrifugal pump is a function of the quantity of liquid passing through the pump in unit time, of the pressure developed by the pump (and hence of the head), of the speed and size of the pump, and of the density and viscosity of the liquid.

In the case of pumps handling very viscous liquids, such as lubricating oils, the flow may not be completely turbulent. As a result, the pump characteristics will be affected by Reynold's number, and a simplified expression of the affinity laws for homologous pumps is not possible. However, in the case of pumps handling water, gasoline, and other light liquids, complete turbulence can be expected, so that it is possible to reduce the affinity laws for homologous pumps operating at the same efficiency to

$$Q_1/N_1D_1^3 = Q_2/N_2D_2^3 \text{ and } H_1/N_1^2D_1^2 = H_2/N_2^2D_2^2$$

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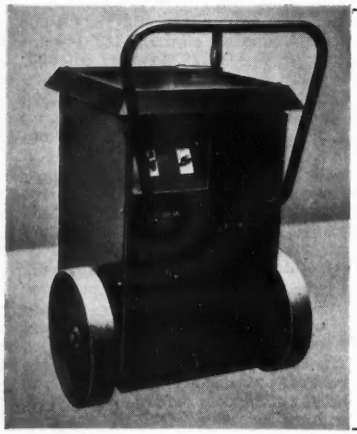

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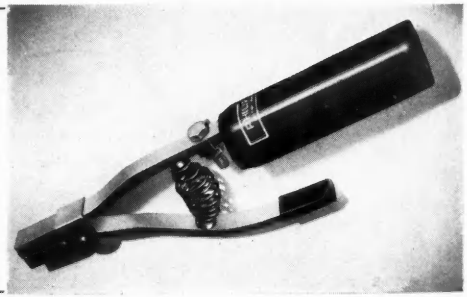

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Low range — 15 to 100 amps. O/C voltage 80/100 volts.
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where Q = quantity flowing through pump, gpm, N = speed of pump impeller, rpm; D = diameter of impeller, in.; H = head developed by pump, ft.

Speed Effect: If the different pumps are considered to be the same pump running at two different speeds N_1 and N_2, then $D_1 = D_2$, and the above equations reduce to $Q_1/Q_2 = N_1/N_2$ and $H_1/H_2 = (N_1/N_2)^2$. Therefore, with homologous pumps of the same size, Q varies directly as N, and H varies as N^2.

The power P required to drive the pump is proportional to the product of Q and H; hence, P varies as N^3 for homologous pumps of the same size handling the same liquid.

Size Effect: For homologous pumps of different sizes D_1 and D_2, but running at the same speed, the equations reduce to

$$Q_1/Q_2 = (D_1/D_2)^3 \text{ and } H_1/H_2 = D_1/D_2^2$$

Therefore, with homologous pumps running at the same speed, Q varies as D^3, and H varies as D^2. The power P required by the pumps then varies as D^5.

Sources of Error: The principal sources of error are, first, errors in measured values, which cause corresponding errors in predicted values, and, second, failure to satisfy fully the requirement of perfect geometrical similarity.

When it is desired to predict the effect of a change in speed of a given pump, the requirement of perfect geometrical similarity is already fully satisfied. Errors in predicted performance will then result only from errors in measured performance, and the effects of such errors are readily determined from the affinity law equations (or from nomograms given in this article).

However, when it is desired to predict the effect of a change in scale of homologous pumps, the requirement of perfect geometrical similarity can rarely, if ever, be fully satisfied. Perfect geometrical similarity implies not only that all corresponding angles be the same and that all corresponding linear dimensions be in the same ratio to each other, but also that all clearances and all surface roughnesses be in the same ratio to each other. As a result, perfect geometrical similarity means geometrical similarity of even microscopic details. Although a quantitative evaluation of these effects cannot at present be made, it has, however, been found from experience that, as long as the change in scale does not exceed ± 25 per cent, the errors in predicted performance are not likely to be greater than 2 or 3 per cent.

STRESS ANALYSIS

Investigation of Stress Waves in Cylindrical Steel Bars

By S. PETERSSON. (From *Acta Polytechnica, Sweden*, Mechanical Engineering Series, Vol. 2, No. 7, 1953, 21 pages, 11 illustrations).

THE pressure bar method devised by Hopkinson has long been used in the study of stress waves. In this method, a cylindrical steel bar is subjected to an impact at one end, the other end being provided with a detachable end-piece in close mechanical contact with the end surface of the bar. The impulse of the stress wave can be determined by measuring the momentum trapped in the detachable end-piece, and the approximate shape of the pressure curve found from repeated measurements made by means of end-pieces of varying length. If the end-piece is replaced by a condenser, the pressure-time curve can be directly recorded, as shown by Davies, on a cathode-ray oscillograph.

In the present investigation, electric wire strain-gauges were used in place of condensers. By means of these gauges and a cathode-ray oscillograph, the stress wave resulting from the pressure produced by a detonating explosive charge on one end of a cylindrical steel bar, 25 mm in diameter and 1 m in length, was recorded.

The duration of the pressure was less than the period of purely radial oscillations and, in this connection, may be regarded as infinitesimal. On account of dispersion, the stress wave is flattened out to a length of about 5 times the diameter of the bar, and is followed by a tail of high-frequency oscillations. These effects were studied experimentally and theoretically. After the stress wave has been reflected a few times from the end surfaces of the bar, the high-frequency oscillations are damped out. At this stage, the wave was studied as a train of harmonic oscillations. The damping of the 1st, 3rd, and 5th harmonics was determined by resolving the wave into its Fourier components.

Owing to dispersion, a wire strain gauge cemented to the surface of the pressure bar does not record the mean stress over the cross-section. On the other hand, if use is made of two wire strain-gauges, fitted at right angles to each other, and if these gauges are employed as two arms of a bridge circuit, it is possible to obtain an indication which is proportional to the mean stress.

A description of the design of the bridge circuit is included.

VIBRATIONS

Plastic Models for Vibration Analysis

By G. O. SANKEY. (From *Machine Design, U.S.A.*, Vol. 25, No. 5, May, 1953, pp. 125-128, 6 illustrations.)

VIBRATION studies of complex structures can easily be made with inexpensive plastic models—an extension in the use of models from purely static tests involving loads and deflections, to dynamic investigations of natural frequencies and modes of motion. This approach presents many advantages in studying systems for which mathematical computation, even by a calculating machine, is complex and uncertain.

In this method, the model is constructed geometrically similar to the prototype structure and usually to some greatly reduced scale. Alternating forces are applied to the model over the frequency range of interest with an electromagnetic driver. A typical resonance curve results, readily interpreted for the prototype by consideration of the differences between mechanical properties of model and prototype materials. Vibration peaks for the structure can then be adjusted safely away from known excitation frequencies.

Mechanical properties of the material are such that the frequencies of interest are low, where vibration excitation and measurement are convenient, even for small-size models of large steel structures. Proper interpretation of test results, however, depends on the properties of the plastics. Since these properties are influenced by temperatures and vibration frequency, they must be carefully evaluated over the range of conditions encountered during actual model tests.

Prototype critical frequencies are readily determined from the model scale and the differences in the mechanical properties of the model and prototype materials. Higher natural frequency of the model due to scaling may be reconciled by choice of a model material that has a low modulus-to-density ratio.

Thermoplastics have several advantages as a dynamic model material. Firm model joints can be obtained through ordinary cementing methods without introducing additional damping in the structure. East of machining and cementing thermoplastics yields a relatively inexpensive, lightweight model that may be excited by existing methods and equipment. Thus, models may be altered quickly to incorporate new design changes.

Plastic models should be useful in vibration studies of many other forms, particularly in the design of such structures as ships, airframes and machine rotors, where vibration characteristics are important.

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The instrument is simple to manipulate, and generally a ring type of specimen can be inserted, centred, and the graph obtained within a minute or two. Repeat readings are obtained more quickly. The Graph shows the amount by which the periphery of the work being tested departs from a truly circular form to an accuracy of three micro-inches (0.000,003 in.) (0,000075 mm.)

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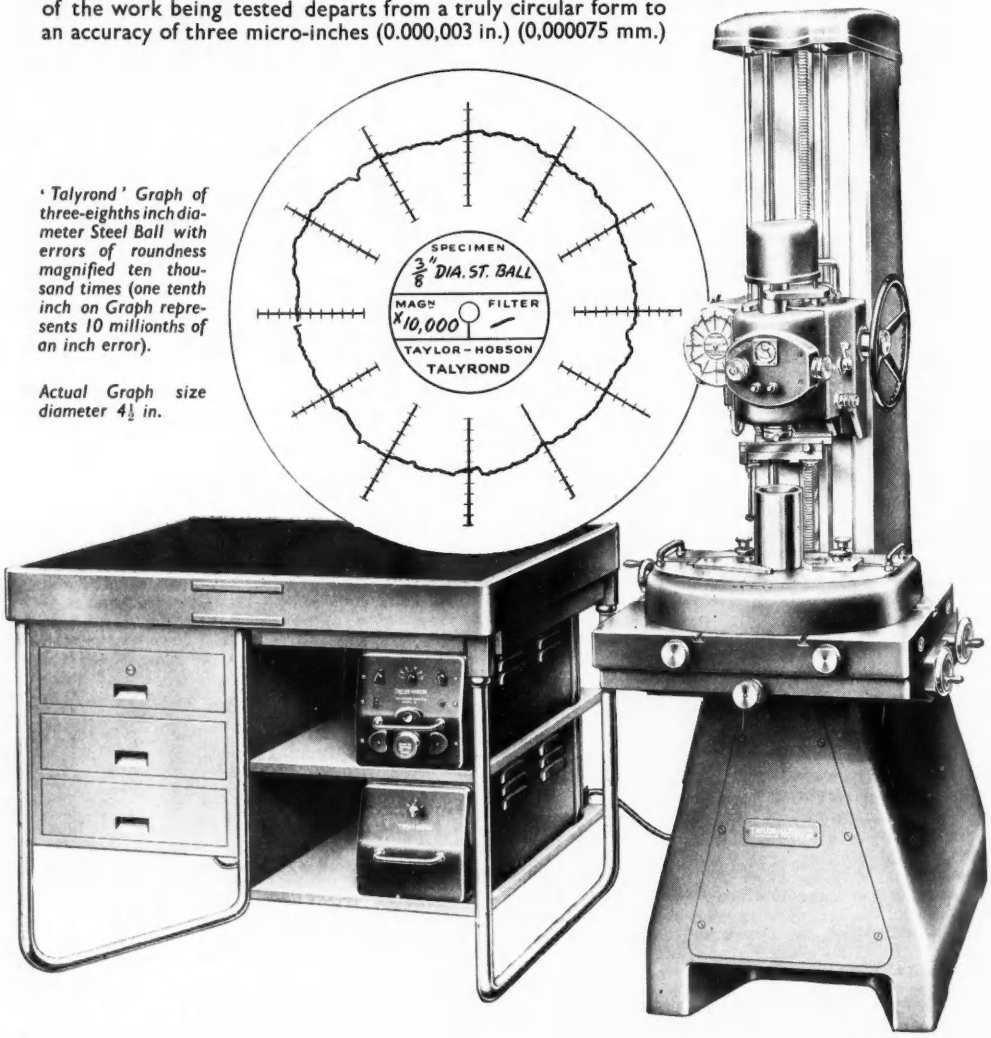

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NEWS OF THE MONTH

PERSONAL

Mr. C. C. Bates, A.M.I.P.E., has been appointed chief welding engineer of Costain—John Brown Ltd., 73 South Audley Street, London, W.1. In addition he will be responsible for technical supervision of their associate company, Welding Supervision Ltd.

Mr. W. Bulloch, A.M.I.Mech.E., has been appointed head of the hydraulic and mechanical materials-handling department of B.V.C. Industrial Constructions Ltd., Terminal House, Grosvenor Gardens, London, S.W.1.

Brigadier J. Clemow has been appointed, by arrangement with the Ministry of Supply, head of guided-weapon development at the research and armament development division of The Fairey Aviation Co. Ltd., Hayes, Middlesex.

Mr. G. J. Corson, A.M.I.E.E., has been appointed manager of the Traction Division of Crompton Parkinson Ltd., Chelmsford, in succession to **Mr. F. H. Beasant,** who has been appointed to the Board of the Anti-Attrition Metal Group of Companies, 56 Victoria Street, London, S.W.1.

Mr. C. E. Dunton, M.A.(Cantab.), M.I.C.E., has been appointed chief civil engineer, and **Mr. T. S. Pick, B.Sc.(Eng.), (Lond.), M.I.E.E., M.Inst.F.,** chief electrical engineer of the London Transport Executive.

Mr. C. Ellis, A.M.I.P.E., has been appointed special director of Edward Pryor & Son Ltd., Sheffield. **Mr. T. F. Newton, A.M.I.P.E.,** has been appointed factory superintendent.

Mr. John Ford, Midlands manager of Paterson Hughes Engineering Co. Ltd., 3 Highfield Road, Edgbaston, Birmingham, has been appointed to the Board of the Company.

Mr. J. P. Ford, M.A., A.M.I.P.E., director of Brush Export Ltd., has been appointed general manager of the Company. He is also director and general manager of Associated British Oil Engines (Export) Ltd., and of National Oil Engines (Export) Ltd., and a director of Brush ABOE (Ireland) Ltd., and of Associated Oil Engines (Marine) Ltd. He has been vice-chairman of the Institute of Export since 1949.

Mr. P. A. Fryatt, M.I.P.E., has been appointed works manager at the new dry shaver factory of Rolls Razor Ltd., at Hemel Hempstead.

Mr. J. Roy Gordon, B.Sc., has been elected vice-president and general manager of the International Nickel Company of Canada Ltd.

Mr. F. L. Harrap, London sales manager and sales director of Ferodo Ltd., brake and clutch lining manufacturers, Chapel-en-le-Frith, has been appointed export sales director of the Company. **Lieut.-Colonel G. S. Sutcliffe, O.B.E.,** works director, has been appointed home sales director. **Mr. S. C. Clifford, F.I.M.,** has joined the Board and has been appointed works director.

Mr. F. H. Harris, B.Sc., A.C.G.I., M.I.P.E., and **Mr. E. H. L. Cooper, M.I.Mech.E., M.I.E.E., M.I.P.E., F.I.I.A.,** have been appointed joint general managers of Henry Meadows Ltd., Wolverhampton.

Mr. A. G. Hayek, A.M.I.P.E., until recently with Thackwell & Hayek Ltd., has formed a company, A. G. Hayek & Partners Ltd., management consultants and industrial engineers with headquarters at Federation House, Stoke-on-Trent.

Mr. P. W. Howard, managing director of British Tyre and Rubber Co. Ltd., Herga House, Vincent Square, London, S.W.1, has been elected President of the Federation of British Rubber Manufacturers' Association, in succession to **Mr. J. H. Lord,** director of the Dunlop Rubber Co. Ltd., St. James House, St. James Street, London, S.W.1.

Professor Willis Jackson, D.Sc., D.Phil., F.R.S., M.I.E.E., who has been Professor of Electrical Engineering at the Imperial College of Science and Technology, University of London, since 1946, has been appointed director of research and education of Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester 17. Dr. Jackson's appointment releases **Dr. Dannatt** for an extension of his present duties as assistant managing director. Professor Jackson has also joined the Board of the Company.

Mr. E. J. H. Jones, M.I.P.E., general manager of Crossley Motors Ltd., Stockport, has been elected a director of the Company.

Mr. A. W. A. Kay, A.M.I.P.E., has been appointed a director of Gerhardy Bros. Ltd., Great Missenden.

Mr. J. Maxwell Laing, B.Sc., A.M.I.Mech.E., has been appointed general sales manager of the Audley Engineering Co. Ltd., Newport, Salop.

Mr. Aubrey Lewis, M.I.P.E., has been appointed general works manager of The Pyrene Co. Ltd., Gt. West Road, Brentford, Middlesex.

Major General Sir Richard Lewis, K.C.M.G., C.B., C.B.E., and **Mr. Edgar W. Percival, F.R.Ae.S., M.S.A.E., M.I.Ae.E., M.I.Mar.E., A.F.I.Ae.S., F.R.S.A.,** have been elected to the Board of Henry Meadows Ltd., Wolverhampton.

Mr. G. S. C. Lucas has been appointed a director and chief electrical engineer of the British Thomson-Houston Co. Ltd., Rugby.

Mr. J. B. Miles, chief engineer of Cincinnati Milling Machines Ltd., Birmingham, for the past fifteen years, has joined Alvis Ltd., Holyhead Road, Coventry, as chief production engineer.

Mr. E. T. Norris, M.I.E.E., M.I.Mech.E., has been appointed consulting engineer to Ferranti Ltd., Hollinwood, Lancashire.

Mr. L. H. Pulfer has been appointed manager of the special lamp department of the British Thomson-Houston Co. Ltd., Crown House, Aldwych, London, W.C.2.

Mr. J. T. Ritchie has been appointed sales manager and local director of Aveling-Barford Ltd., Grantham, Lincolnshire, and **Mr. N. C. Earl** has been appointed works manager of the Company.

Mr. J. D. Roberts, A.M.I.P.E., has been appointed works manager of Windolite Ltd., Harlow.

Mr. G. E. Smith, M.A.(Cantab.), has been appointed contracts manager of Brush Bagnall Traction Ltd., Loughborough.

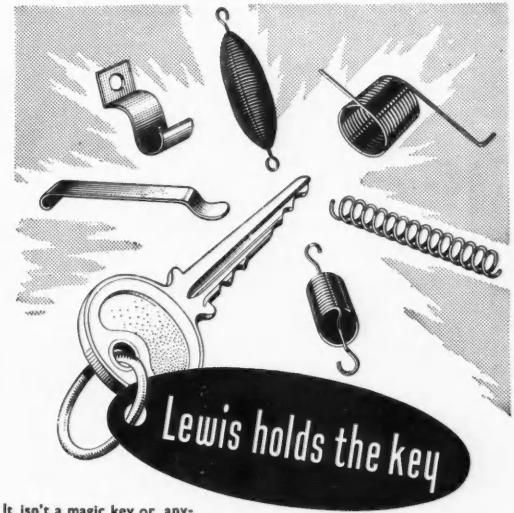
Mr. Arthur Storey, a director of the North Eastern Marine Engineering Co. (1938) Ltd., Wallsend, has joined William Doxford and Sons Ltd., Pallion, Sunderland, as director and deputy manager of the engineering department.

Mr. K. W. West has been appointed technical sales manager of the Crosby Valve and Engineering Co. Ltd., Ealing Road, Wembley, Middlesex. Previous to this appointment, Mr. West was with the Bristol's Instrument Co. Ltd.

Mr. Arthur Wood, M.I.P.E., managing director of C. E. Johansson Ltd., Dunstable, has been elected to the Board of Henry Meadows Ltd., Wolverhampton, and H. Widdop & Co. Ltd., Keighley.

Mr. C. E. Wragg, sales manager of Kayser, Ellison & Co. Ltd., Carlisle Steel Works, Sheffield, has been elected local director of the Company.

THE SUMMERSON GROUP OF COMPANIES announce the following appointments: **Mr. Roland Winn** is appointed a director of Thomas Summerson & Sons Ltd. He joined the company in 1905 and has been company secretary since 1933. **Mr. A. F. Tosh,** works manager of Summerson's Foundries Ltd., is made a director of that Company. Mr. Tosh has worked in the foundry industry for over 50 years, and prior to joining Summersons in 1942 he was with Baldwins Ltd. (now the Steel Company of Wales) as manager of their Landore Foundry. He has been a member of the British Iron & Steel Institute for over 20 years. **Mr. C. Whitehouse,** works manager of Summersons Railway Workshops at Spennymoor has also been appointed a director of Copelaw Engineering Co. Ltd.,



It isn't a magic key or anything like that. It just so happens that we have been called in on so many tricky questions over the last thirty years that we now know the answer to most of them. Wouldn't it be a good idea to see us about your new project? *Established 1919. A.I.D. approved.*

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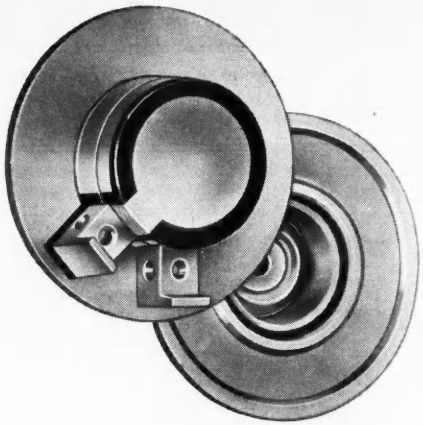

puzzle picture?

Our photograph shows two views of a component which comprises two metal diecastings joined together and yet completely insulated from each other by a plastics moulding. No seeping of moisture can be tolerated and the placing of the inner component must be extremely accurate. This tricky problem solved by our Birmingham technicians, the resulting assemblies go to play their part in an electro acoustic instrument of great intricacy.

National Plastics development engineers and product designers are ready at all times to collaborate with potential users of moulded plastics. The list of new applications developed and put into production in recent months is most impressive.

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TWO NATIONAL PLASTICS COMPANIES

MP122 L.G.B.

a light engineering subsidiary. Mr. Whitehouse joined Thomas Summerson & Sons Ltd. in 1920. **Mr. George V. Newlands** has joined Thomas Summerson & Sons Ltd. as works engineer.

BUSINESS NOTES

Easterbrook Allcard & Co. Ltd., manufacturers of engineers small tools, Penistone Road, Sheffield 6, have moved their London office to more spacious and modern premises at 7/9 Glentworth Street, Baker Street, London, N.W.1.

Erratum. On page 185 of our May issue, in our note on Isomantle Surface Heaters, the illustration included showed in error special Isopanels used for maintenance of equal temperatures on Radar equipment and not the suphanating pot described.

The Hercules Powder Co. Ltd., 140 Park Lane, London, W.1, have concluded an agreement to act as sole distributors for the United Kingdom of Akulon, a polyamide (nylon) type injection and extrusion moulding material manufactured by Algemene Kunstzijde Unie, N.V., Arnhem, Holland.

Alan Muntz & Co. Ltd., Heston Airport, Hounslow, Middlesex, United Kingdom and British Commonwealth licensees for the Pescara free-piston engine system announce that Charles D. Holmes & Co. Ltd., Hull, have recently signed a sub-licence agreement. Charles D. Holmes becomes the first British firm to take a manufacturing sub-licence for this type of prime mover.

Dunlop Special Products Ltd. has opened a new London depot and warehouse in Kingsbury Road, N.W.9 (Colindale 7033).

Mr. B. J. Wardle has been appointed southern manager of the company's compositions division with headquarters at the Kingsbury Works.

NEW TESTING FRAME AT THE NAVAL CONSTRUCTION RESEARCH ESTABLISHMENT

The First Lord of the Admiralty, the Rt. Hon. J. P. L. Thomas, M.P., will open a building containing a large testing frame at the Naval Construction Research Establishment, Dunfermline, on Monday, July 20th.

The purpose of the large testing frame, which, so far as is known, is the first of its kind in the world, is to make experiments on full-scale structures. It has become increasingly evident that the behaviour of some materials—steel in particular—can be fully and correctly assessed only from experiments made on structures in which the thicknesses of the materials, the sizes of members and the methods of connecting them together are faithfully represented at full scale. Thus the large testing frame will open a new era in the accuracy and scope of the information on heavy structures available to designers.

The frame consists of a cellular steel construction of internal dimensions 69 ft long, 33 ft wide, 39 ft high, and external dimensions 85 ft long, 45 ft wide, 51 ft high. Each " cell " in the roof, walls and floor is 6 ft square and can accommodate a hydraulic jack capable of exerting a force of up to 500 tons in any direction up to an inclination of 45 degrees to the plane of the " cell " in which it is placed. Additional equipment, not yet available, but at present under construction, will enable loads up to 2,000 tons to be exerted horizontally along the longitudinal axis of the frame. The arrangements allow for four loads to be applied simultaneously by an intricate hydraulic loading system. The strains experienced by the structure under test are distantly recorded.

One end of the frame is hinged and power is provided to enable it to swing outwards so that the structure to be tested can be placed in position.

The foundation and supports of the frame have been the subject of special design consideration.

The frame and its associated powering arrangements, control gear and recording equipment are housed in a building 200 ft long, 80 ft wide and 85 ft high. Special heating arrangements are installed and include hot-water pipes embedded in the conerete floor to ensure uniformity of temperature during the course of an experiment.

The equipment has been built to general requirements specified by the Director of Naval Construction, Admiralty. Freeman, Fox and Partners, undertook the detailed design under the personal attention, in the initial stages, of the late Sir Ralph Freeman. The frame itself has been constructed by Sir William Arrol, Ltd., who are also manufacturing the 2,000-ton loading equipment. The 500-ton loading equipments have been manufactured by Tangyes Ltd. The powering, controlling and recording gear are the results of the combined efforts of many firms, particularly Towler Bros., Avery, Evershed & Vignoles, and Macklow-Smith.

This testing facility, which will be of the utmost value in assisting the design of warship structures, will also, where defence requirements permit, be available for investigating commercial ship-building and civil engineering problems.

The first job to be carried out in the new frame will be a test of the bow structure supporting the steam catapults in the aircraft carrier *Ark Royal*. This new type of catapult, which was put through its paces so successfully in H.M.S. *Perseus*, imposes very heavy forces on its supporting structure when an aircraft is launched and it is necessary to be quite sure that the structure built into the ship is strong enough to withstand these forces, yet not stronger than is necessary. Any weight used unnecessarily for such a purpose reduces the margin available for fighting purposes.

Experience in the *Perseus* does not help in the matter, because the catapult was then supported on a heavy but simple structure built on top of the flight deck. This was quite acceptable for trials but could not be used in an operational ship where the support must be incorporated into the underdeck structure. Such a structure is far too complicated for close calculation. In the absence of the new testing frame it would be necessary to allow more generous factors of safety to ensure that no part was too highly stressed. Thus unnecessary weight would be worked into the ship. This test provides an excellent example of the way in which the frame will enable better ships to be built.

AERO-ENGINE DESIGNERS WORK TO REDUCE NOISE

Aero-engine designers are co-operating with University and Government research workers in an attempt to reduce the noise of aircraft engines.

The work done so far gives hope that noise levels may be appreciably reduced in the future, both by the use of silencers and because some of the new jet engines under development—by-pass and ducted-fan types—are inherently less noisy.

Although only jet engines and propeller engines are at present in commercial use, the noise level of rocket motors, ram jets and reheat engines is also being studied.

Aerodrome authorities are also studying how to cut down the noise of engines being run up on the ground.

The principal cause of noise from jet engines is the high frequency noise from the high velocity and turbulence of the jet stream as it rushes rearward from the jet pipe. Fortunately the by-pass type of engine (such as the *Conway*, which will be fitted to a new Vickers transport), tends to have a lower jet velocity than earlier types of jet, so it is expected to be proportionately less noisy than a straight jet of the same power would be.

Fortunately too, suppressors can be designed so that when they are fitted to the jet pipe they reduce the noise without any considerable reduction in thrust. Fuel economy is unaffected and the only change noted has been a very slight increase in jet pipe temperature when the suppressor is fitted.

The most successful suppressor so far tested was designed at the College of Aeronautics, Cranfield. It consists of a ring with metal fingers or teeth sticking out from it, which is attached to the rear of the jet nozzle.

This silencer has now been tested full-scale by Rolls-Royce on a *Derwent* jet and its effectiveness checked with the teeth set at different angles to the axis of the engine. This type of suppressor could be particularly effective in reducing the noise of an engine fitted with reheat.

Besides the teeth suppressors, there have been experiments with suppressors of gauze, needle-type and larger vanes. The Universities of Manchester and Southampton, and government establishments such as the Royal Aeronautical Establishment and the National Physical Laboratory, have made various tests on scale models and a corpus of knowledge is now being built up which will

"have a breakdown?" ...

. . . asked His Oil Highness, The Tecalemit Man.

"No thanks," replied the Works Manager, "we've just had one!"

The Tecalemit Man smiled. "Then I've got some statistics that will interest you," he said.

"If," said the W.M. peevishly, "you're going to tell me that all the one-wheeled bicycles in Leeds placed end to end go three times round the Albert Memorial—I know!"

"Much more interesting," grinned The Tecalemit Man, "is the fact that if all the breakdowns that could have been prevented by Automatic Lubrication were placed end to end, they'd equal over 80% of your yearly quota!"

The W.M. brightened. "That sounds like a big saving," he said. "Yes," answered The Tecalemit Man, "you must lubricate to accumulate!"

Tecalemit lubrication systems—fully automatic, semi-automatic or manually operated—feed every bearing with the correct amount of oil or grease at the correct intervals of time, regularly . . . unfailingly . . . efficiently.

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TECALEMIT

The Authority on Lubrication

PLYMOUTH, ENGLAND

14.8

help determine the exact cause and nature of noise and how to reduce it.

Work on more advanced engine types has been done by the N.P.L. which has tested a pressure-jet developed by the Fairey Company; a pulse-jet built by Saunders-Roe has been tested at the University of Southampton.

Running-up pens have been built at London Airport, using an experimental wall of asbestos sheeting fixed to steel scaffolding. Tests were made with a *Comet* and *Viking* aircraft and the noise reduction was so considerable that a more permanent and extentive wall is now being built there. This is a V-shaped wall forming a kind of pen, into which the aircraft are taken before engine runs.

PRODUCTIVITY SCHOOL FOR EXECUTIVES

Leading industrialists believe that Britain's future depends on the proper education of potential managers. As a result, they have sponsored, with university interests, a summer school for young executives to be held at Worcester College, Oxford, from July 27th to August 22nd.

The school will be an experiment, and if successful, will be enlarged and repeated. Young men between the ages of 25 and 34 who hold junior executive posts in industry will learn from practical men with long experience of factory administration and from University teachers with specialist knowledge of economics, law, statistics, and history.

Subjects for study include: the basic structure of industry, management techniques, the country's economic position and the effects of industry on the country's social life.

The committee responsible for the arrangement is under the chairmanship of Sir Hugh Chance, director of Chance Bros. Ltd. The school will be directed by Mr. John Ayres, managing director, Petters Ltd., Staines, petrol and diesel engine manufacturers.

Mr. Ayres said that "the school is an experiment. It is born of the need for bringing home to management the necessity for adopting completely new techniques to increase productivity in British industry.

"Productivity can be increased tremendously provided the right attitude of mind can be adopted by all sections of industry from organised labour to top management. Management bears the first and biggest responsibility for achieving that productivity.

"How much we can increase productivity depends on how management can adapt itself to change and how it leads the people it controls. All grades of management must have a truer appreciation of the country's problems than can be gained from working within the narrow limits of their own jobs.

"For that reason we felt the need to get together a representative cross section of intermediate management and try to develop the new methods which are so vital to the nation's survival.

O.E.E.C. APPOINTS PRODUCTIVITY DIRECTOR

A Director for the European Productivity Agency was appointed today by decision of the Council of the Organisation for European Economic Co-operation. He is Dr. Karl Peter HARTEN, 52-year-old German productivity expert.

The European Productivity Agency came into existence, within the framework of O.E.E.C., on 1st May 1953, as a result of a decision taken by the Council of Ministers on 24th March. It was then stated that the main purpose of the Agency would be "to seek, develop and promote the most suitable and effective methods for increasing productivity in individual enterprises, in the various sectors of economic activity in the Member countries, and over the whole field of their economics. To this end, it shall undertake and promote measures tending to the acceptance and adoption of the best and most modern techniques and to the removal of factors limiting their adoption." It was further agreed that "in carrying out these purposes the Agency shall be guided by the principles that competition should be encouraged while any business practices which result in decreased production and higher prices should be discouraged; that the benefit obtained through an increase in productivity should be shared to the mutual benefit of consumers, owners and workers; and that cooperation of management and labour organisations, where there is good will on both sides, will promote these purposes."

The Agency is operated under the authority of O.E.E.C. by the Productivity and Applied Research Committee and the Secretary-General of the Organisation. An Advisory Board consisting of Members appointed by the Council and chosen in their personal capacity from among nationals of Members or Associated countries—the latter consisting of the United States and Canada—assists the Committee. Each year a Programme of Action will be drawn up for implementation by the Agency; one of the new Director's first tasks will be to draw up this Programme of Action, together with the budget of the Agency, for the period 1st July 1953/30th June 1954.

LIGHT ALLOY FOR WORLD'S LARGEST SLUDGE SCRAPERS

Six sludge scrapers recently installed at the Nottingham Corporation Sewage Disposal Works are the largest in the world, each having an overall span of 114 ft 4½ in. They are made of Duralumin "H" light alloy structural section and plate, manufactured by James Booth and Company Limited of Birmingham, and the contractors were Thatcher Lucas & Company Limited of Great Bridge, Tipton, Staffs. "Duralumin" is being increasingly used for sewage equipment, because it is remarkably resistant to the corrosive effects of the effluents.

NEW LINK TESTING POWER FACTOR METER

The range of link testing ammeters and wattmeters manufactured by The General Electric Co. Ltd. has been extended by the introduction of a Link testing power factor meter. This instrument, covered by British patent No. 645668, follows closely the lines of the

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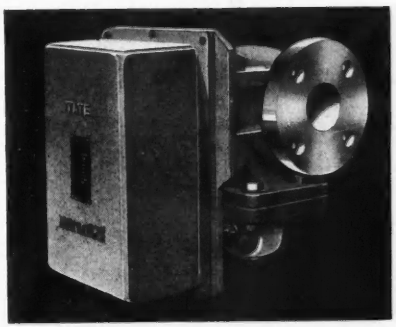

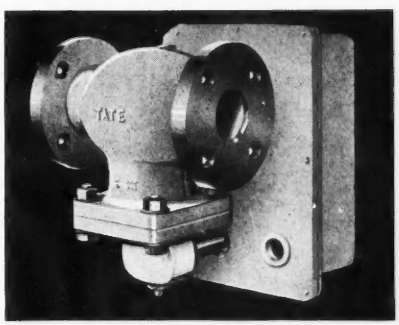

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VICTORY WORKS

BRADFORD

'PHONE: 28348/9 'GRAMS: VALVE.

existing G.E.C. link testing instruments and comprises a link unit and plug-in indicator. The link unit has a hinged pole-piece which is used to encircle a current carrying conductor without breaking the circuit. Leads similar to those used with the G.E.C. link testing wattmeter, plug into the handle and enable the voltage component to be connected by shrouded crocodile clips.

The indicator, which is the same size as the ammeter and watt-meter indicators, plugs into the link unit and has two scales, one of which is used for circuits carrying currents of 50 to 100 amp and the other for circuits in which the current is 100 to 250 amp. Both scales cover the range 0·5 lag-1-0·5 lead and the scale length is 2½ inches.

The indicator, which is a true single-phase power factor meter of the moving iron type using a split phase circuit, has three jack connections which plug into the link system. The standard ammeter indicators can also be used in the power factor links, so that an initial reading of current can be made to determine which scale on the power factor meter should be used.

The standard links are suitable for use on conductors up to 1⅞ in. dia. and a larger set are in production for use on conductors of greater diameter, busbars, fuses, etc.

The instrument can be used to measure power factor in single-phase and polyphase circuits provided the neutral is available and the phase voltage does not exceed 250 volts. In the case of three-phase unbalanced load circuits an average of the power factor in each phase must be taken.

An external resistance unit is available to enable the instrument to be used on circuits with a line voltage up to 600V.

For delta-connected circuits with no neutral available a special lead is available incorporating an artificial neutral point resistance which is used in place of the standard lead.

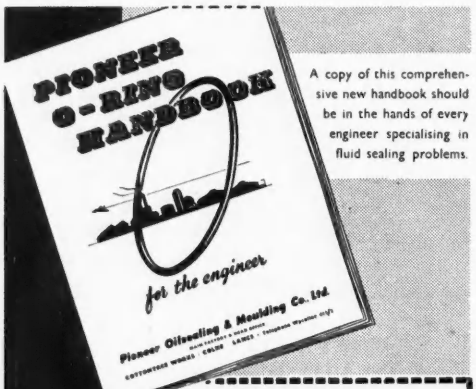
BRITISH STANDARDS

(*Copies of British Standards may be obtained from the British Standards Institution, 24, Victoria Street, London, S.W.*1.)

Solid Drawn Copper and Copper Alloy Tubes (B.S. 378 : 1953). The British Standards Institution has just published a revised edition of B.S. 378 which supersedes the 1941 edition.

The previous issue covered solid drawn 70/30 brass and 70/29/1 brass tubes. The present revision includes in addition to these alloys, tubes in copper, aluminium brass, copper-nickel and aluminium bronze (7 per cent aluminium).

The requirements for tubes for screwed glands, and screwed glands for condensers included in the earlier edition have however been omitted, and will form the subject of a separate standard. Price 2/6.



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Classified Advertisements.

The rate for all classified advertisements is 6*d. per word; in bold print* 9*d. per word; minimum order* 6*s. Box number advertisements* 1*s. extra. Instructions together with remittance must be received not later than the* 3*rd of each month for advertisements to appear in the same month's issue.*

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ARMSTRONG SIDDELEY MOTORS CAR DIVISION

have a vacancy for a

HIGHLY EXPERIENCED AUTOMOBILE DESIGNER

with considerable experience in the design of complete chassis including engine and transmission. This position offers interest and scope for a man of considerable experience and initiative. Reply fully in strictest confidence to Reference MC2, **Armstrong Siddeley Motors,** Coventry.

ARMSTRONG SIDDELEY MOTORS require Senior Engine Designer aged 30/36 years for work of exceptional interest on an entirely new design project offering wide scope for imagination and inventiveness. Applicants must be first class works trained mechanical designers with at least Higher National Certificate and a thorough knowledge of high speed I.C. engine design. Reply in detail to Reference HSR.1. Personnel Manager, Armstrong Siddeley Motors, Coventry.

ARMSTRONG SIDDELEY require a first class Mechanical Designer aged 26/32 for their Project Design Office. Applicants must be works trained designers with at least Higher National Certificate and a sound background experience of aero engine design. The position offered is one of great interest and is an exceptional opportunity for a young engine designer to expand his experience in the gas turbine industry. Reply in detail to Reference HSR.3, Personnel Manager, Armstrong Siddeley Motors, Coventry.

ARMSTRONG SIDDELEY MOTORS LIMITED, Coventry, have vacancies for Technical Assistants for research and experimental work on aircraft gas turbines; particularly on compressors, turbines and aerodynamic flow problems. Engineering degree, H.N.C. or equivalent necessary. Write in detail to Reference TA, Personnel Manager, **Armstrong Siddeley Motors Limited,** Coventry.

YOUNG ENGINEER required for training by Somerset Firm producing centrifugal pumps and electric motors. Applicants should be good mathematicians with sound basic knowledge of hydraulics and preferably some electrical design knowledge. Salary in accordance with qualifications. Interview, London. State fullest particulars of training and experience.—Box No. S.M. 167.

ENGINEER required to **TAKE CHARGE** of Design and Development of Turbo-Hydraulic Transmission up to 1000 h.p. Technical qualifications to University Degree Standard and sound theoretical background in hydrodynamics essential, preferably with some design experience on similar types of machinery. Good salary for responsible position. State age, experience and present salary level. Application will be treated confidently.—

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RECONDITIONED EX-ARMY HUTS, and manufactured buildings. Timber, Asbestos, Nissen Type, Hall Type, etc. All sizes and prices. Write, call or telephone—**Universal Supplies (Belvedere) Ltd.,** Dept. 50, Crabtree Manorway, Belvedere, Kent. Tel.: ERITH 2948.

NEW TILTING TABLE GUILLOTINE 0-30° for cutting steel plates with bevelled edges prior to welding. Cap. 78 in. wide × ⅜ in. thick mild steel. Steel plate construction. Motorised pump 400/3/50. Photo **F. J. Edwards Ltd.,** 359 Euston Road, London.

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